Chapter 1
Elementary and Secondary Mathematics and Science Education

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Highlights

Student Learning in Mathematics and Science

Gains in average mathematics scores on the National Assessment of Educational Progress (NAEP) between 2007 and 2009 leveled off for grade 4 and continued for grade 8. For 12th graders, average mathematics scores improved from 2005 to 2009.

- ♦ From 1990 to 2007, average mathematics scores increased by 27 points for fourth graders. Scores then leveled off in 2009 across almost all demographic groups and performance levels and among students at public and private schools.
- ♦ At grade 8, average mathematics scores steadily gained 20 points from 1990 to 2009, with improvement for most demographic groups, performance levels, and school types.
- ♦ At grade 12, average mathematics scores improved by 3 points from 2005 to 2009, with improvement patterns similar to those of eighth graders.

Score gaps among demographic groups narrowed over time but remained substantial.

- ♦ At grades 4, 8, and 12, white and Asian/Pacific Islander students had significantly higher scores than their black, Hispanic, and American Indian/Alaska Native counterparts. Students from higher income families also performed significantly better than their peers from lower income families. Although boys scored higher than girls, the differences were relatively small.
- ♦ At grade 4, some gaps narrowed over time. Between 1990 and 2009, the score gap between white and black students fell from 32 to 26 points, the score gap between public and private school students dropped from 12 to 7 points, and the score gap between low- and high-performing students narrowed by 9 points.

Few students in ninth grade mastered high level algebra skills in 2009, according to the High School Longitudinal Study assessment.

- ♦ A majority of ninth graders demonstrated proficiency in lower level algebra skills such as algebraic expressions (86%) and multiplicative and proportional thinking (59%).
- ♦ Few students reached proficiency in systems of equations (18%) and linear functions (9%), the two highest algebra skills assessed.

Relatively few students at grades 4, 8, and 12 reached their grade-specific proficiency levels in science on the 2009 NAEP assessment. Science scores varied significantly across student subgroups.

- ♦ At all three grade levels, whites, Asians/Pacific Islanders, and students from higher income families scored significantly higher than their counterparts. Boys also scored higher than girls at all three grade levels, but the difference was substantially smaller.

In both 2006 and 2009, U.S. 15-year-olds scored below those of many other developed countries in the Programme for International Student Assessment, a literacy assessment designed to test mathematics and science. Nonetheless, U.S. scores improved from 2006 to 2009.

- ♦ The average mathematics literacy score of U.S. 15-year-olds declined about 9 points from 2003 to 2006, and then rose about 13 points in 2009, placing the United States below 17 of 33 other members of the Organisation for Economic Co-operation and Development (OECD).
- ♦ The average science literacy score of U.S. 15-year-olds was not measurably different from the 2009 OECD average, though it improved by 3 points from 2006 to 2009. The U.S. score was lower than the score of 12 out of 33 other OECD nations participating in the assessment.

Student Coursetaking in High School Mathematics and Science

High school graduates in 2009 continued an upward trend of earning more credits in mathematics and science, including *advanced* mathematics and science courses.

- ♦ The average number of credits earned in all mathematics courses was 3.9 in 2009, up from 3.2 in 1990. The average number of credits earned in all science courses was 3.5 in 2009, up from 2.8 in 1990.
- ♦ Graduates in 2009 earned an average of 1.7 credits in advanced mathematics and 1.9 credits in advanced science and engineering courses, compared with 0.9 and 1.1 credits, respectively, in 1990.

The percentages of students completing advanced mathematics and science courses increased in all subject areas.

- ♦ In 2009, 76% of all graduates earned a credit for algebra II, compared with 53% of all graduates in 1990.
- ♦ The percentage of students earning a credit in precalculus/analysis more than doubled since 1990, with 35% of graduates completing precalculus/analysis in 2009, compared with 14% in 1990.
- ♦ From 1990 to 2009, the percentage of students earning a credit in advanced chemistry increased from 45% to 70%. Increased rates were also seen in advanced biology (28% to 45%) and physics (24% to 39%).
- ♦ The percentage of students taking algebra I before high school increased. Twenty-six percent of high school graduates took algebra I before high school in 2009, up from 20% in 2005.

Although students in all racial/ethnic groups are earning more advanced mathematics and science credits, differences among these groups have persisted.

- Asian/Pacific Islander students earned the most credits in advanced mathematics, an average of 2.4 credits in 2009. Hispanics and blacks earned the fewest credits in advanced mathematics, approximately 1.4 credits. White students earned more credits (1.8) than black or Hispanic students, but fewer than Asian/Pacific Islander students. Similar patterns were seen in science coursetaking.

Teachers of Mathematics and Science

The percentage of public middle and high school mathematics and science teachers with advanced degrees and full certification has increased since 2003, but school differences persist.

- Fifty-four percent of mathematics teachers and 58% of science teachers had earned a master's or higher degree in 2007, compared with 48% and 52%, respectively, in 2003.
- Eighty-seven percent of mathematics and science teachers held regular or advanced teaching certification in 2007—a significant increase for science teachers from 83% in 2003.
- Degree and certification differences persist among schools with different student populations. For example, 69% of science teachers in low-poverty schools had advanced degrees versus 49% in schools with high poverty rates.
- In 2007, about one in five new mathematics and science teachers was hired through an alternative certification program. Relatively more of these teachers were found in high-poverty or high-minority schools. For example, 26% of mathematics teachers in schools with the highest poverty levels became teachers through alternative certification, compared with 12% of those in schools with the lowest poverty levels. (Some alternative certification programs aim to place teachers in high-poverty schools.)

Novice teachers—those with 3 or fewer years of experience—are more prevalent at high-poverty and high-minority schools.

- In 2007, about 20% of all public middle and high school mathematics and science teachers were novice teachers. Proportionally, more of those in high-minority schools were novices: 22% of mathematics teachers and 25% of science teachers were novices, compared with 13% and 15% in low-minority schools.

Most high school teachers of mathematics and science taught in field (i.e., they had a degree or full credential in the subject matter they taught) in 2007. In-field teaching is less prevalent among middle school teachers but has increased among middle school mathematics teachers since 2003.

- In-field mathematics teachers in public middle schools increased from 53% in 2003 to 64% in 2007. Approximately 70% of middle school science teachers taught in field in both 2003 and 2007.
- Eighty-eight percent of high school mathematics teachers in 2007 taught in field, as did 93% of biology/life science teachers and 82% of physical science teachers.

Participation has increased in new teacher induction programs, which provide professional development and support during early teaching years, and the gap in participation rates between teachers at schools with different demographics has narrowed.

- In 2007, 79% of new mathematics teachers and 73% of new science teachers in public middle and high schools had participated in an induction program. The corresponding rates in 2003 were 71% among mathematics teachers and 68% among science teachers.
- In 2003, 63% of new mathematics teachers in high-minority schools had been in an induction program, 25 percentage points fewer than their counterparts at low-minority schools. In 2007, this gap narrowed to 8 percentage points because of higher participation in high-minority schools.

More than three-quarters of mathematics and science teachers in 2007 said that they had received some professional development in their subject matter. However, few participated for as many hours as research suggests is desirable.

- In 2007, 83% of mathematics teachers and 77% of science teachers in public middle and high schools said they had received professional development in their subject matter during the previous 12 months.
- Among those with professional development in their subject matter, 28% of mathematics teachers and 29% of science teachers received 33 hours or more. Research has suggested that 80 hours or more may be required to affect teacher knowledge and practice.

Teachers' views of their working conditions varied with the characteristics of the student population at their schools, but some differences have narrowed since 2003.

- Half of mathematics and science teachers at high-poverty or high-minority schools viewed student tardiness and class cutting as interfering with teaching. In contrast, a third of their counterparts at low-poverty and low-minority schools expressed this view.
- Some differences have narrowed since 2003. Then, about half of mathematics teachers at high-poverty schools saw student apathy as a serious problem, compared with 12% at low-poverty schools. In 2007, that gap had narrowed by about 20 percentage points, reflecting more positive views of teachers at high-poverty schools. The gap in reported lack of student preparedness for learning also shrank.

Transition to Higher Education

Rates of students graduating within 4 years of entering ninth grade (“on-time” graduation) increased slightly in recent years, but gaps among racial/ethnic groups persist.

- In 2009, 76% of students completed high school on time, up from 73% in 2001.
- The on-time graduation rates of black and Hispanic students increased between 2006 and 2009: from 59% to 64% for black students and from 61% to 66% for Hispanic students. Wide gaps remained between the on-time graduation rates of black and Hispanic students and those of white students, who graduated at a rate of 82% in 2009.

The U.S. high school graduation rate lags behind those of most other developed (OECD) nations.

- The United States ranked 18th out of 25 OECD countries for which graduation rate data were available in 2008.
- According to OECD estimates, the United States had an average graduation rate of 77% compared with the OECD average of 80%.

The majority of U.S. high school graduates enroll in a postsecondary institution immediately after high school completion.

- Seventy percent of 2009 high school graduates had enrolled in a postsecondary institution by the October following high school completion, an increase of 19 percentage points since 1975.
- Relatively more female graduates than male graduates enrolled immediately in postsecondary education in 2009 (74% versus 66%).
- Students from high-income families enrolled at a higher rate (84%) than did students from middle-income (67%) or low-income families (55%).
- The rate for white students was 71%, compared with 63% for black and 62% for Hispanic students.

Introduction

National and state education policies continue to focus on improving learning by U.S. students. Policy goals include increasing student achievement overall, reducing disparities in performance among key subgroups of students, and moving the international ranking of U.S. students from the middle to the top over the next decade (The White House n.d.). STEM fields (science, technology, engineering, and mathematics) have been a strong focus of recent reform efforts, including developing common core standards across states, strengthening curricula, promoting advanced coursetaking, enhancing teacher quality, raising graduation requirements, and expanding technology use in education.

This chapter presents indicators of elementary and secondary mathematics and science education in the United States, drawing mainly on data from the National Center for Education Statistics (NCES) of the U.S. Department of Education. Table 1-1 presents an overview of the topics covered in this chapter and the indicators used to illuminate the topics.

The chapter begins by summarizing the most recent data on student achievement in mathematics and science, focusing on recent trends in student performance, changes in performance gaps, and the relative international standing of U.S. students.[1] It also includes new indicators of mathematics and science performance by students in charter schools, trends in mathematics achievement among very high-scoring students, and the results of an algebra assessment of ninth graders.

The chapter then focuses on mathematics and science coursetaking in high school. This edition includes new data on trends in total and advanced mathematics and science credits earned by high school graduates and enrollment in algebra before high school. It also discusses the "common core standards" effort and state participation in that effort, subjects new to this volume.

The chapter turns next to public school mathematics and science teachers, examining their educational attainment, licensure, experience, professional development, attrition, salaries, and working conditions. All teacher indicators in this chapter use the latest available data, which derive from the 2007–08 Schools and Staffing Survey (SASS).

The chapter closes with indicators of students' transitions from secondary to postsecondary education—the subject of chapter 2 in this volume. Updated indicators include on-time high school graduation rates, immediate college enrollment rates, and international comparisons of high school graduation rates and postsecondary enrollment.

The chapter focuses primarily on overall patterns but also reports variation in access to educational resources by schools' minority concentration and poverty level and in student performance by sex, race/ethnicity, and family and school characteristics. Whenever a difference or change over time is cited in this chapter, it is statistically significant at the 0.05 probability level.[2]

Student Learning in Mathematics and Science

Increasing overall student achievement, especially lifting the performance of low achievers, is a central goal of education reform in the United States. This goal is reflected in the federal No Child Left Behind Act of 2001 (NCLB), which mandates that all students in each state reach the proficient level of achievement by 2014. This goal is also highlighted in the more recent federal Race to the Top program, which calls for states to design systemic and innovative educational reform strategies to improve student achievement and

Table 1-1
Indicators of elementary and secondary school mathematics and science education

Topic	Indicator
Student learning in mathematics and science	• Trends in 4th, 8th, and 12th graders' mathematics performance through 2009 • 4th, 8th, and 12th graders' science performance in 2009 • Ninth graders' algebra performance in 2009 • International comparisons of 15-year-olds' mathematics and science literacy in 2003, 2006, and 2009
Student coursetaking in mathematics and science	• High school graduation requirements and curriculum standards • Trends in mathematics and science course completion by high school graduates from 1990 to 2009
Mathematics and science teachers	• Degrees, certification, and experience of public middle and high school teachers in 2008 • Professional development of teachers in 2008 • Teacher attrition from 1988 to 2008 • Teacher salaries and working conditions in 2008
Student transitions to higher education	• On-time high school graduation rates in 2008 • International comparisons of secondary school graduation rates in 2008 • Immediate college enrollment from 1975 to 2009 • International comparisons of college enrollment rates in 2008

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close performance gaps.[3] The federal government also targets funds directly to low-performing schools through the School Improvement Grants program,[4] for example, to support changes needed in the lowest achieving schools across the nation. These and other efforts to improve achievement are ongoing.

How has the performance of U.S. students changed over time? Are achievement gaps narrowing? How do U.S. students compare with their peers in other nations? This section addresses these questions by examining over time a series of indicators of student performance in mathematics and science in the United States. It begins with a review of recent results of mathematics and science assessments of U.S. students in grades 4, 8, and 12, followed by a review of the performance of ninth graders in algebra in 2009. The section ends by placing U.S. student performance in an international context, comparing the mathematics and science literacy of U.S. 15-year-olds with that of their peers in other countries.

Mathematics and Science Performance in Grades 4, 8, and 12

The National Assessment of Educational Progress (NAEP), a congressionally mandated program, has monitored changes in U.S. students' academic performance in mathematics and science since 1969. NAEP has two assessment programs: main NAEP and NAEP Long-Term Trend (LTT).[5] The main NAEP assesses national samples of 4th and 8th grade students at regular intervals and 12th grade students occasionally. These assessments are updated periodically to reflect contemporary curriculum standards in various subjects, including mathematics and science. (In 2014, NAEP will conduct its first nationwide assessment in technology and engineering literacy; see sidebar "Development and Content of NAEP Technology and Engineering Literacy Assessment.")

The NAEP LTT assesses the performance of students ages 9, 13, and 17. Its content framework has remained the same since it was first administered in 1969 in science and in 1973 in mathematics, permitting analyses of trends over more than 3 decades. This section examines recent performance results using main NAEP data only. Findings based on NAEP LTT data have been reported in previous editions of *Science and Engineering Indicators,* and no new data were available from the NAEP LTT for this volume.[6]

Reporting NAEP Results

The main NAEP reports student performance in two ways: scale scores and achievement levels. Scale scores place students along a continuous scale based on their overall performance on the assessment. For mathematics assessments, scales range from 0 to 500 for grades 4 and 8 and from 0 to 300 for grade 12. For science assessments, scales range from 0 to 300 for all grades.

NAEP also reports student results in terms of achievement levels. Developed by the National Assessment Governing Board (NAGB), achievement levels are intended to measure how well students' actual achievement matches the achievement expected of them in different subjects assessed by NAEP. Based on recommendations from educators, policymakers, and the general public, NAGB sets three achievement levels for all subjects assessed by NAEP (NCES 2010, 2011):

- *Basic* denotes partial mastery of materials appropriate for the grade level.
- *Proficient* indicates solid academic performance.
- *Advanced* represents superior academic performance.

Based on their test scores, students' performance can be categorized as *below-basic*, *basic*, *proficient*, and *advanced*.[7] Because achievement levels were developed independently at each grade level, they cannot be compared across grade levels.[8] Although the NAEP achievement levels are useful in understanding student results and have been widely used by national and state officials, there is disagreement about whether these achievement levels are appropriately defined. A study commissioned by the National Academy of Sciences asserted that NAEP achievement levels were "fundamentally flawed" (Pellegrino, Jones, and Mitchell 1999). The National Mathematics Advisory Panel concluded in 2008 that NAEP scores for the two highest achievement categories (proficient and advanced) were set too high (NMAP 2008). Both NCES and NAGB acknowledged this controversy, and NCES, upon review of congressionally mandated evaluations of NAEP, has recommended that achievement levels be used on a trial basis and interpreted with caution (NCES 2011).

The following review of NAEP results reports both average scale scores and achievement levels, focusing on the percentage of students performing at or above the proficient level both overall and among various subgroups of students.

Trends in Mathematics Performance Through 2009

Average Score. For grade 4, the average mathematics score increased by 27 points from 1990 to 2007 and leveled off from 2007 to 2009 (figure 1-1). This overall trend was repeated in almost all demographic subgroups, across students at all performance levels (i.e., 10th to 90th percentiles[9]), and among students at both public and private schools (table 1-2).

For grade 8, the average mathematics score increased steadily from 1990 to 2009 with a total gain of 20 points over the period, including a statistically significant 2-point gain from 2007 to 2009 (figure 1-1). Rising scores were widespread, occurring among both male and female students; almost all racial/ethnic groups; students from families that were financially disadvantaged and advantaged; students in the low-middle, middle, and high ranges of performance (i.e., 25th to 90th percentiles); and students attending public schools (table 1-2) (see sidebar "Mathematics and Science Achievement in Charter Schools"). The score at the 10th percentile, however, was unchanged from 2007 to 2009, indicating that mathematics performance did not improve significantly among very low-performing students during this period.

Development and Content of NAEP Technology and Engineering Literacy Assessment

Beginning in 2014, the National Assessment of Educational Progress (NAEP) will administer the first nationwide student assessment in technology and engineering literacy. The framework defines key terms such as *technology* and *engineering literacy,* determines the content to be assessed, specifies the types of assessment questions to be asked, and guides the development of the assessment instrument (WestEd 2010).

Although the federal No Child Left Behind Act of 2001 requires that every student be “technologically literate by the time the student finishes the eighth grade,” the law itself is vague in defining what technological literacy is, leaving states to determine what it means and how it should be assessed. Some states require engineering/technology education for students in at least some grades, but few have adopted formal assessments in this area (Metiri Group 2009). Technology- and engineering-related courses are typically offered in middle and high schools as electives or are embedded in other subject areas, such as science or social studies (WestEd 2010). Overall, coursetaking in these subjects is not widespread: in 2009, about 3% of high school graduates had taken an engineering course and 6% an engineering/science technology course (Nord et al. 2011). Currently, there are no national standards for K−12 engineering or technology education. Implementing such standards is difficult given limited experience with engineering/technology education at the K−12 level and insufficient numbers of teachers qualified to deliver instruction in this area (National Academy of Engineering 2010).

Definitions of Technology and Engineering Literacy. For the purpose of developing national assessments in this area, the NAEP framework defines technology, engineering, and technology and engineering literacy as follows (WestEd 2010, pp. 1–4):

- *Technology* is any modification of the natural or designed world done to fulfill human needs or desires.
- *Engineering* is a systematic and often iterative approach to designing objects, processes, and systems to meet human needs and wants.
- *Technology and engineering literacy* is the capacity to use, understand, and evaluate technology as well as to understand technological principles and strategies needed to develop solutions and achieve goals.

Areas To Be Assessed. The 2014 NAEP assessment of technology and engineering literacy will test students in the following three areas:

- *Technology and Society* covers the interaction of technology and people; effects of technology on society and the natural world; and questions of ethics, equity, and responsibility that arise from those effects.
- *Design and Systems* includes the nature of technology; the engineering design process by which technologies are developed; and basic principles of dealing with everyday technologies, including maintenance and troubleshooting.
- *Information and Communication Technology* involves computers and software learning tools; networking systems and protocols; and the selection and use of hand-held digital devices and other technologies for accessing, creating, and communicating information and for facilitating creative expression.

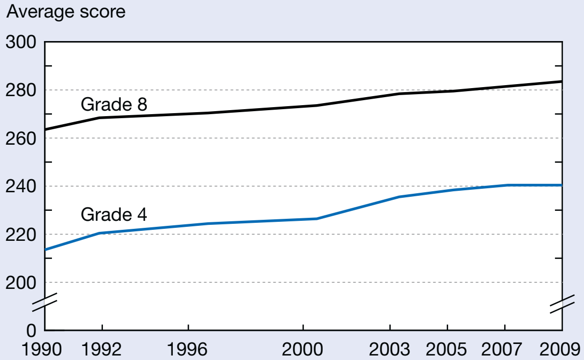
For examples of questions, see http://www.nagb.org/publications/frameworks/prepub_naep_tel_framework_2014.pdf (in chapters 3 and 4). Note that the grade level for these sample questions has not yet been determined.

For grade 12, only 2005 and 2009 results are examined here; substantial revisions of the mathematics framework for the 2005 assessment made comparison with earlier assessments impossible.[10] Between 2005 and 2009, the average mathematics score for students in grade 12 increased by 3 points (appendix table 1-1). Improvement occurred across the board: for both sexes, across all racial/ethnic subgroups, for all performance levels, and among public school students (table 1-2).[11] The gains in average scores were about 3−5 points for many subgroups, with the exception of Asian/Pacific Islander and American Indian/Alaska Native students, who posted gains of 12 and 10 points, respectively, from 2005 to 2009.

Achievement Level. Trends in the percentages of students in grades 4, 8, and 12 reaching the proficient level parallel the scale score trends. The percentage of fourth grade students performing at or above the proficient level increased steadily through 2007 but remained unchanged in 2009. Eighth grade students, on the other hand, showed continuous improvement from 1990 to 2009. Among 12th grade students, the percentage of proficient students increased from 2005 to 2009 (appendix table 1-2).

Despite these gains, the percentage of students reaching the proficient level remains low. In 2009, the percentage of students performing at or above proficient was 39% for 4th graders, 34% for 8th graders, and 26% for 12th graders.

Figure 1-1
Average NAEP mathematics scores of students in grades 4 and 8: Selected years, 1990–2009



NAEP = National Assessment of Educational Progress

NOTES: NAEP mathematics assessment scores range from 0 to 500 for grades 4 and 8. From 1996 on, data shown are for students allowed to use testing accommodations.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of NAEP 1990, 1992, 1996, 2000, 2003, 2005, 2007, and 2009 mathematics assessments, National Center for Education Statistics. See appendix table 1-1.

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Trends in Mathematics Performance of Top Students

Although increasing student achievement is the central goal of educational reform in the United States, policies and reform efforts are aimed mainly at improving the achievement of low-achieving students (Hanushek, Peterson, and Woessmann 2010; Loveless 2008; NSB 2010a). Little nationally representative research has been conducted on high-achieving students.

Advances in STEM, however, often depend on originality and leadership from exceptionally capable individuals. Although such individuals are not easily identified, data on students who score unusually well on standardized assessments provide some indication of performance trends among highly capable students. The following analysis uses NAEP assessment data to focus on students who score in the top 1% of mathematics performance in grades 4 and 8.

In 2009, the 37,000–38,000 fourth and eighth grade students who performed at or above the 99th percentile on the NAEP mathematics assessment resembled higher performing students in the general population.[12] However, compared with fourth and eighth graders nationwide, these top performers were more likely to be male, to be white or

Table 1-2
Changes in NAEP mathematics scores of students in grades 4, 8, and 12, by student and school characteristics: Selected years, 1990–2009

	Grade 4		Grade 8		Grade 12[a]
Student and school characteristic	1990–2009	2007–09	1990–2009	2007–09	2005–09
All students	↑	≈	↑	↑	↑
Sex					
Male	↑	≈	↑	↑	↑
Female	↑	≈	↑	↑	↑
Race/ethnicity					
White	↑	≈	↑	↑	↑
Black	↑	≈	↑	↑	↑
Hispanic	↑	≈	↑	↑	↑
Asian/Pacific Islander	↑	≈	↑	↑	↑
American Indian/Alaska Native	S	↓	S	≈	↑
Free/reduced-price lunch[b]					
Eligible	↑	≈	↑	↑	↑
Not eligible	↑	≈	↑	↑	↑
Score in percentile					
10th	↑	≈	↑	≈	↑
25th	↑	≈	↑	↑	↑
50th	↑	≈	↑	↑	↑
75th	↑	≈	↑	↑	↑
90th	↑	≈	↑	↑	↑
School type					
Public	↑	≈	↑	↑	↑
Private	↑	≈	↑	≈	NA

↑ = increase; ≈ = no change; ↓ = decrease; S = suppressed; NA = not available

NAEP = National Assessment of Educational Progress

[a]Changes in mathematics scores for grade 12 presented only for 2005 to 2009 because prior assessments were not comparable with those in or after 2005, and there was no grade 12 mathematics assessment in 2007.
[b]Information on student eligibility for subsidized lunch program, a measure of family poverty, first collected in 1996; comparisons in 1990–2009 columns cover 1996 to 2009.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of NAEP 1990, 1996, 2005, 2007, and 2009 mathematics assessments, National Center for Education Statistics. See appendix table 1-1.

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Mathematics and Science Achievement in Charter Schools

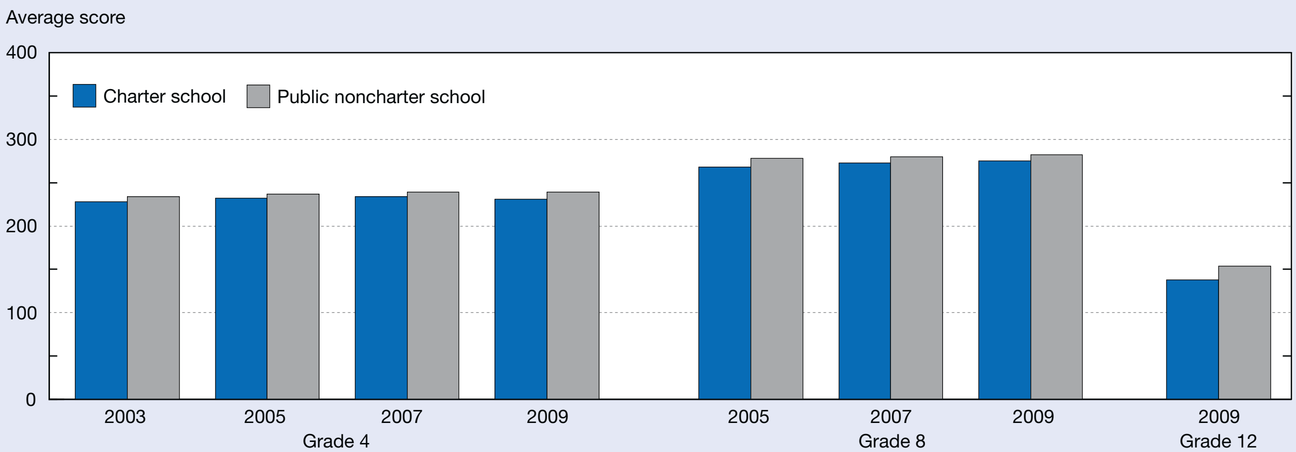
Charter schools are public schools that provide elementary or secondary education to students under a specific charter granted by the state legislature or other appropriate authority (Hoffman 2008). These schools are independent of direct control by local school districts and operate free of many regulations applicable to traditional public schools. Data from the National Alliance for Public Charter Schools (http://www.publiccharters.org/dashboard/home) show that between 2000 and 2010, the number of charter schools more than tripled and the number of students attending these schools increased almost fivefold. In 2009–10, there were about 5,000 charter schools in 40 states and the District of Columbia with a total of 1.6 million students (3.4% of all U.S. public school students).

Comparison of student performance in charter versus traditional public schools is difficult because students in charter schools are self-selected (Garcia 2008; Grady and Bielick 2010). Some parents may enroll their children in charter schools because their children are struggling academically. Other parents may desire greater parent involvement or control. Still others may choose charter schools because they are dissatisfied with some aspect of local public schools. These selection factors may result in student populations in charter schools that are different from those in traditional public schools.

The data from the National Assessment of Educational Progress show that although average mathematics performance of fourth and eighth graders in charter schools improved from 2000 to 2009, charter school students overall had consistently lower scores than their counterparts in traditional public schools, and the gaps persisted over time (figure 1-A). In 2009, the average mathematics score of 12th graders in charter schools was also lower than that of their counterparts in traditional public schools. No measurable difference in average science scores, however, was found between students in charter and noncharter public schools (special NSF tabulations).

To mitigate the effects of selection factors, researchers have employed various research designs to control for different student characteristics in charter and noncharter schools (Abdulkadiroglu et al. 2009; Berends et al. 2010; Braun, Jenkins, and Grigg 2006; CREDO 2009; Hoxby, Murarka, and Kang 2009; Lubienski and Lubienski 2006; Zimmer et al. 2009). These studies produced mixed results on the effectiveness of charter schools, with impacts ranging from small (either positive or negative) to statistically insignificant (Betts and Tang 2008). There is wider variation in performance among charter schools than among public noncharter schools (Braun, Jenkins, and Grigg 2006). This may be due in part to wide variation in charter schools' operation and organizational structure (Buddin and Zimmer 2005; Zimmer et al. 2003).

Figure 1-A
Average NAEP mathematics scores of public school students in grades 4, 8, and 12, by charter school status: Selected years, 2003–09



NAEP = National Assessment of Educational Progress

NOTES: NAEP mathematics assessment scores range from 0 to 500 for grades 4 and 8 and from 0 to 300 for grade 12. Charter schools not identified prior to 2003 for grade 4, 2006 for grade 8, and 2009 for grade 12.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of NAEP 2003, 2005, 2007, and 2009 mathematics assessments, National Center for Education Statistics. See appendix table 1-1.

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Asian/Pacific Islander, and to come from higher income families (table 1-3).[13] Top performers in grade 8 were more likely than eighth graders overall to have parents with a college degree.[14]

Average mathematics scores for fourth grade students in this top 1% were not only much higher than those for the average fourth grader (304 versus 240 in 2009), they also exceeded the eighth grade average (304 versus 283 in 2009)[15] (table 1-4). Average mathematics scores for this top group rose steadily from 2000 to 2005 and then remained flat after 2005. Between 2000 and 2009, the scores for the top 1% of fourth graders increased by 9 points, compared with a 14-point increase in scores for all fourth graders.

Like fourth graders, the top 1% of eighth graders had much higher mathematics scores than average (e.g., 366 versus 283 in 2009). However, their trend pattern differed from that of their fourth grade counterparts: average mathematics scores for top eighth graders remained essentially unchanged between 2000 and 2003 and then increased steadily after 2003. The average scores for all eighth graders also increased (appendix table 1-1) so that the improvements overall and among the top 1% were not measurably different.

Table 1-4

Average NAEP mathematics scores of all students in grades 4 and 8 and students in the top 1%: Selected years, 2000–09

Grade	2000	2003	2005	2007	2009
Grade 4					
All students	226	235	238	240	240
Top 1%	295	298	303	303	304
Grade 8					
All students	273	278	279	281	283
Top 1%	358	359	362	364	366

NAEP = National Assessment of Educational Progress

NOTES: NAEP mathematics assessment scores range from 0 to 500 for grades 4 and 8. Top 1% of students are those with NAEP mathematics scores ≥ the 99th percentile for their grade level.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of NAEP 2000, 2003, 2005, 2007, and 2009 mathematics assessments, National Center for Education Statistics.

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Table 1-3

Distribution of all students in grades 4 and 8 and students in the top 1% taking the NAEP mathematics assessments, by student characteristic: 2009

(Percent distribution)

Student characteristic	Grade 4		Grade 8	
	All students	Students in top 1%	All students	Students in top 1%
All students	100.0	100.0	100.0	100.0
Sex				
Male	50.8	62.4	50.3	57.9
Female	49.2	37.7	49.7	42.1
Race/ethnicity				
White, non-Hispanic	56.5	69.7	58.5	75.4
Black, non-Hispanic	16.1	1.0	15.2	0.6
Hispanic	21.2	1.5	19.9	1.4
Asian/Pacific Islander	5.0	27.5	5.2	22.2
American Indian/Alaska Native	1.2	0.3	1.1	0.3
Free/reduced-price lunch				
Not eligible	52.4	94.7	57.7	95.0
Eligible	47.7	5.3	42.3	5.0
Highest level of parental education				
High school or less	NA	NA	27.1	1.9
Some college	NA	NA	18.2	4.4
College degree or above	NA	NA	54.8	93.7

NA = not available

NAEP = National Assessment of Educational Progress

NOTES: Students in the top 1% are those with NAEP mathematics scores ≥ 99th percentile for their grade level. Percentages may not add to 100 because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of NAEP 2009 mathematics assessments, National Center for Education Statistics.

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Changes in Performance Gaps in Mathematics

Despite improvement in recent decades, gaps in mathematics performance persisted among many student subgroups (appendix table 1-1). In general, boys performed slightly better than girls.[16] Gaps between students of different racial/ethnic backgrounds or family income remained large, with white and Asian/Pacific Islander students and those from higher income families posting significantly higher scores than their counterparts who were black, Hispanic, or American Indian/Alaska Native students or who were from lower income families. Large gaps were also observed by school type, with private school students scoring significantly higher than their peers in public schools.[17]

Some reductions in these gaps were observed among fourth grade students (table 1-5). For example, the white-black gap in mathematics performance among fourth grade students narrowed from 32 to 26 scale points between 1990 and 2009 because of larger gains by black students[18] (appendix table 1-1). The gap between public and private school fourth grade students also narrowed during the same period because of greater gains by public school students. Finally, fourth graders' score at the 10th percentile rose faster than that at the 90th percentile, reducing the gap between low- and high-performing students in grade 4. No similar gap reductions between 1990 and 2009 were observed at grades 8 or 12.

Science Performance in 2009

The framework for the NAEP science assessment was updated in 2009 to reflect advances in science, curriculum standards, assessments, and research on science learning (NCES 2011). The new assessment placed a greater emphasis on what students can do with science knowledge. Because the framework changed significantly, the results from the 2009 assessment cannot be compared with earlier ones (NAGB 2008). This section, therefore, discusses only the 2009 assessment results, which will serve as a baseline for measuring students' progress on future science assessments. For earlier results on NAEP science assessments, see *Science and Engineering Indicators 2008*, pp. 1-13 and 1-14 (NSB 2008).

As in mathematics, science performance varies significantly by student demographics and by school type. At grade 4, the average score for boys was slightly higher than that for girls (151 versus 149) (figure 1-2). Differences by racial/ethnic background and family income were larger: scores for white and Asian/Pacific Islander students were at least 28 points higher than those for black, Hispanic, and American Indian/Alaska Native students, and the score for students from higher income families was 29 points higher than that for students from lower income families. Students from private schools outperformed their peers in public schools by 14 points. Similar performance gaps based on sex, race/ethnicity, and family income were observed among students in grades 8 and 12 (appendix table 1-3).

Most students failed to reach the proficient level on the science assessment. In 2009, 34% of 4th graders, 30% of 8th graders, and 21% of 12th graders performed at or above the proficient level in science (appendix table 1-4). At grade 12, only 4% of black students, 8% of Hispanic students, and 8% of low-income students reached the proficient level.

Algebra Performance of Ninth Graders in 2009

The first year of algebra is a prerequisite for higher level mathematics courses in high school (NMAP 2008), opening doors to more advanced mathematics and a college

Table 1-5
Changes in NAEP mathematics score gaps between selected groups of students, by grade level: Selected years, 1990–2009

	Change in score gap		
	Grade 4	Grade 8	Grade 12
Score gap between selected groups of students	1990–2009	1990–2009	2005–09[a]
Males and females	≈	≈	≈
Whites and blacks	↓	≈	≈
Whites and Hispanics	≈	≈	≈
Students from low-income families and those from other families[b]	≈	≈	≈
Low-performing students and high-performing students[c]	↓	≈	≈
Public school students and private school students	↓	≈	NA

≈ = no change; ↓ = decrease; NA = not available

NAEP = National Assessment of Educational Progress

[a]Changes in gaps for grade 12 presented only for 2005 to 2009 because prior assessments were not comparable with those in or after 2005.
[b]Information on student eligibility for subsidized lunch program, a measure of family poverty, first collected in 1996; comparisons in 1990–2009 columns cover 1996 to 2009.
[c]Gap between scores at the 10th and 90th percentiles.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of NAEP 1990, 1996, 2005, and 2009 mathematics assessments, National Center for Education Statistics. See appendix table 1-1.

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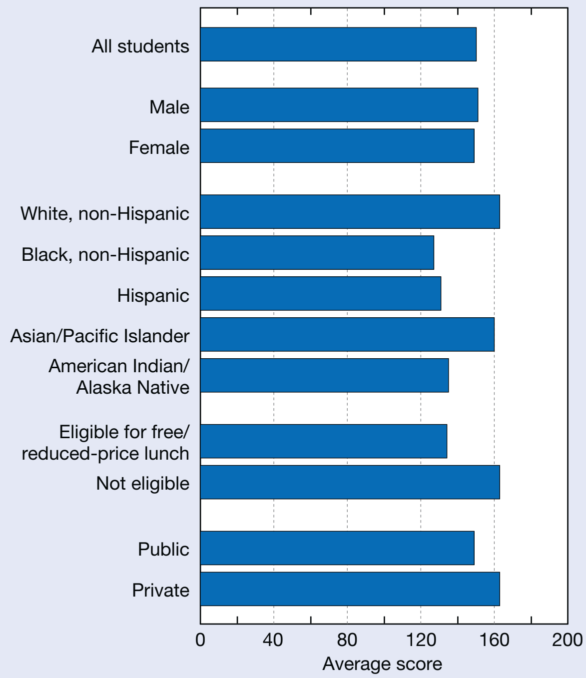
Figure 1-2
Average NAEP science scores of students in grade 4, by student and school characteristics: 2009



NAEP = National Assessment of Educational Progress

NOTE: NAEP science assessment scores range from 0 to 300 for grade 4.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of NAEP 2009 science assessment, National Center for Education Statistics. See appendix table 1-3.

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preparatory curriculum. These, in turn, are associated with higher college attendance rates, higher college graduation rates, greater job readiness, and higher earnings once students have entered the workforce (Achieve, Inc. 2008; Adelman 2006; Allensworth and Nomi 2009; Bozick and Lauff 2007; Gamoran and Hannigan 2000; Ma and Wilkins 2007; Nord et al. 2011). The following section draws on the High School Longitudinal Study of 2009 (HSLS:09) to examine mathematics performance in algebra among a cohort of ninth graders in 2009.

HSLS:09, a nationally representative longitudinal study of more than 21,000 ninth graders in 944 schools, is following a sample of students who were ninth graders in 2009 through secondary and postsecondary education, providing insight into students' learning experiences from the beginning of high school into postsecondary education and work. The base year data collection of HSLS included an algebra assessment that provides indicators of ninth graders' proficiency in five specific algebraic skill areas (Ingels et al. 2011). These skill areas are arranged in a hierarchy such that proficiency at a higher level implies proficiency at all levels below it. In order of increasing difficulty, these five skill areas are as follows:

- ♦ Level 1, Algebraic expressions: Understands algebraic basics including evaluating simple algebraic expressions and translating between verbal and symbolic representations of expressions.
- ♦ Level 2, Multiplicative and proportional thinking: Understands proportions and multiplicative situations and can solve proportional situation word problems, find the percent of a number, and identify equivalent algebraic expressions for multiplicative situations.
- ♦ Level 3, Algebraic equivalents: Understands algebraic equivalents and can link equivalent tabular and symbolic representations of linear equations, identify equivalent lines, and find the sum of variable expressions.
- ♦ Level 4, Systems of equations: Understands systems of linear equations and can solve such systems algebraically and graphically and characterize the lines (parallel, intersecting, collinear) represented by a system of linear equations.
- ♦ Level 5, Linear functions: Understands linear functions and can find and use slopes and intercepts of lines and functional notation.

In 2009, a majority of ninth graders were proficient in lower level algebra skills such as algebraic expressions (86%) and multiplicative and proportional thinking (59%) (figure 1-3). Proportions demonstrating proficiency in more advanced algebra skills were lower and decreased as the difficulty level increased. Only 9% of ninth graders reached proficiency in linear functions, the highest algebra skill level assessed by HSLS.

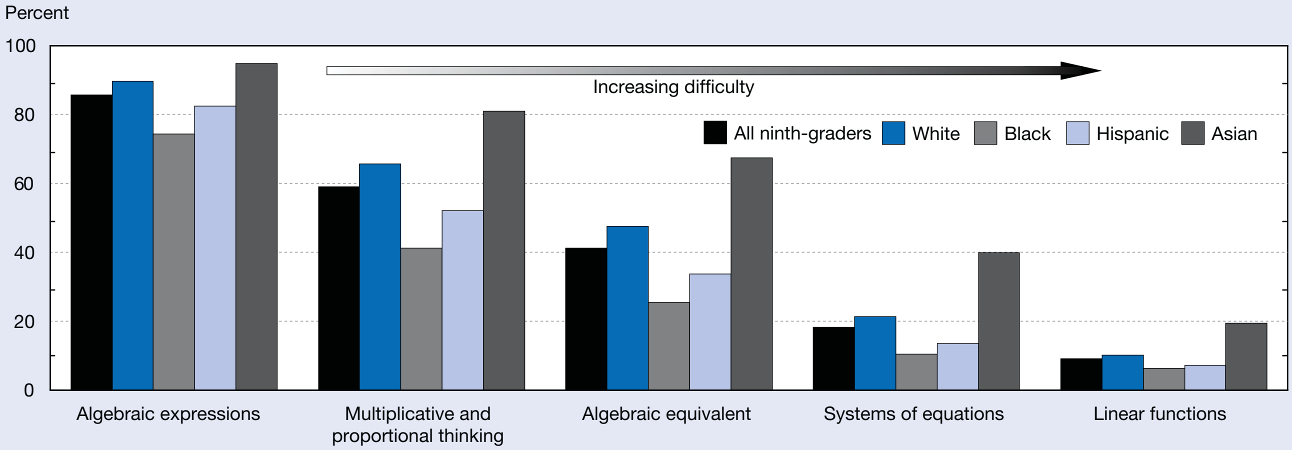
Though there were no gender differences in algebra performance (appendix table 1-5), considerable differences were found among racial/ethnic subgroups (figure 1-3). In each skill area, Asian and white students demonstrated proficiency at higher rates than did black and Hispanic students. For example, 20% of Asians and 10% of whites were proficient in linear functions, compared with 6−7% of blacks and Hispanics.

Differences by parents' education were also considerable (appendix table 1-5). In every skill area assessed, proportionally more students whose parents had a bachelor's or advanced degree achieved proficiency than those whose parents had a high school education or less. For example, 35% of students whose parents had an advanced degree mastered systems of equations and 16% mastered linear functions; the corresponding percentages for students whose parents had not completed high school were 10% and 6%, respectively.

International Comparisons of Mathematics and Science Performance

This section examines the relative international standing of U.S. students in mathematics and science using assessment data from the Programme for International Student

Figure 1-3
Ninth-graders proficient in various algebra skill areas, by race/ethnicity: 2009



NOTES: Skill areas are arranged in a hierarchy such that proficiency in a given area assumes proficiency in all lower areas. "All ninth-graders" bars also include students in other racial/ethnic categories that are not shown separately.

SOURCE: Ingels SJ, Dalton B, Holder TE, Lauff E, Burns, LJ, *High School Longitudinal Study of 2009 (HSLS:09): A First Look at Fall 2009 Ninth-Graders*, NCES 2011-327 (2011). See appendix table 1-5.

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Assessment (PISA).[19] Sponsored by the Organisation for Economic Co-operation and Development (OECD) and initially implemented in 2000,[20] PISA assesses the performance of 15-year-olds in mathematics and science literacy every 3 years. Most countries participating in PISA are OECD members, although the number of participating non-OECD nations or regions has been increasing. Most OECD countries are economically advanced nations.

PISA is a literacy assessment, not a curriculum-based assessment; it measures how well students apply their knowledge and understanding to real-world situations.[21] The term "literacy" indicates its focus on the application of knowledge learned in and out of school. In the PISA mathematics assessment, for example, students are asked to estimate an area, compare the best price for buying a product, or interpret the statistics in a news report or government document. In the PISA science assessment, students are asked to discuss acid rain, interpret erosion at the Grand Canyon, or predict the results of a controlled experiment (see sidebar "Sample Items from PISA").

Mathematics Literacy Among U.S. 15-Year-Olds

Despite recent improvement, U.S. PISA scores in mathematics remain consistently below the OECD average and also below those of many non-OECD countries (figure 1-4). On the most recent PISA test in 2009, the U.S. average score of 487 fell below the OECD average of 496 and was lower than the scores of 17 of 33 other OECD nations, including Republic of Korea (546), Finland (541), Switzerland (534), Japan (529), Canada (527), and the Netherlands (526) (appendix table 1-6). The U.S. score was also lower than scores in several non-OECD regions/countries/economies, such as Shanghai-China (600), Singapore (562), and Hong Kong (555). In 2009, U.S. students demonstrated higher mathematical literacy than students in only 5 out of 34 OECD countries (Greece, Israel, Turkey, Chile, and Mexico).

The top mathematics performers in the United States trailed behind their peers in many other nations as well. In 2009, the U.S. score at the 90th percentile in mathematics was 607, lower than the corresponding score in 12 of 33 other OECD nations (620−659) (OECD 2010b).

Science Literacy Among U.S. 15-Year-Olds

U.S. students performed relatively better in the PISA science assessment. The average science literacy score of U.S. 15-year-olds improved by 3 points from 2006 to 2009 (figure 1-4). Whereas U.S. students scored lower than the OECD average in 2006 (489 versus 498), this gap was not evident in 2009 (502 versus 501). The U.S. gains in science since 2006 were mainly driven by improvements at the bottom of the performance distribution; performance at the top remained unchanged (OECD 2010b).

Despite improvement, the 2009 U.S. score (502) was below that of 12 OECD nations (512−554) (appendix table 1-6). For example, U.S. students scored lower than students in 5 top-performing OECD nations (Finland, Japan, Republic of Korea, New Zealand, and Canada) by 27−52 points. U.S. students also lagged behind their peers in (non-OECD) Shanghai-China, Hong Kong, and Singapore (by 40−73 points), The U.S. 90th percentile score in scientific literacy was 629, below the corresponding scores in 7 of 33 other OECD nations (642−667) (OECD 2010b). Thus, U.S. top performers in science did better relative to other countries than did U.S. students on average.

Sample Items from PISA

Sample Items for Mathematics

1) *A result of global warming is that the ice of some glaciers is melting. Twelve years after the ice disappears, tiny plants, called lichen, start to grow on the rocks. Each lichen grows approximately in the shape of a circle. The relationship between the diameter of this circle and the age of the lichen can be approximated with the formula:*

$$d = 7.0 \times \sqrt{(t-12)} \quad \text{for } t \geq 12$$

where d represents the diameter of the lichen in millimeters, and t represents the number of years after the ice has disappeared. Using the formula, calculate the diameter of the lichen, 16 years after the ice disappeared.

Correct answer: 14 mm.

Difficulty level: Correct answer corresponding to 484 score points on the PISA mathematics scale ranging from 1 to 1,000.

2) *In Mei Lin's school, her science teacher gives tests that are marked out of 100. Mei Lin has an average of 60 marks on her first four Science tests. On the fifth test she got 80 marks.*

What is the average of Mei Lin's marks in Science after all five tests?

Correct answer: 64.

Difficulty level: Correct answer corresponding to 556 score points on the PISA mathematics scale ranging from 1 to 1,000

Sample Items for Science

1) *Mary Montagu was a beautiful woman. She survived an attack of smallpox in 1715 but she was left covered with scars. While living in Turkey in 1717, she observed a method called inoculation that was commonly used there. This treatment involved scratching a weak type of smallpox virus into the skin of healthy young people who then became sick, but in most cases only with a mild form of the disease. Mary Montagu was so convinced of the safety of these inoculations that she allowed her son and daughter to be inoculated. In 1796, Edward Jenner used inoculations of a related disease, cowpox, to produce antibodies against smallpox. Compared with the inoculation of smallpox, this treatment had less side effects and the treated person could not infect others. The treatment became known as vaccination.*

What kinds of diseases can people be vaccinated against?

A. Inherited diseases like haemophilia.

B. Diseases that are caused by viruses, like polio.

C. Diseases from the malfunctioning of the body, like diabetes.

D. Any sort of disease that has no cure.

Correct answer: B. Diseases that are caused by viruses, like polio.

Difficulty level: Correct answer corresponding to 436 score points on the PISA science scale ranging from 1 to 1,000.

2) *Regular but moderate physical exercise is good for our health.*

Is this an advantage of regular physical exercise:

Physical exercise helps prevent heart and circulation illnesses. Yes / No

Physical exercise leads to a healthy diet. Yes / No

Physical exercise helps to avoid becoming overweight. Yes / No

Correct answer: Yes, No, Yes in that order.

Difficulty level: Correct answer corresponding to 545 score points on the PISA science scale ranging from 1 to 1,000.

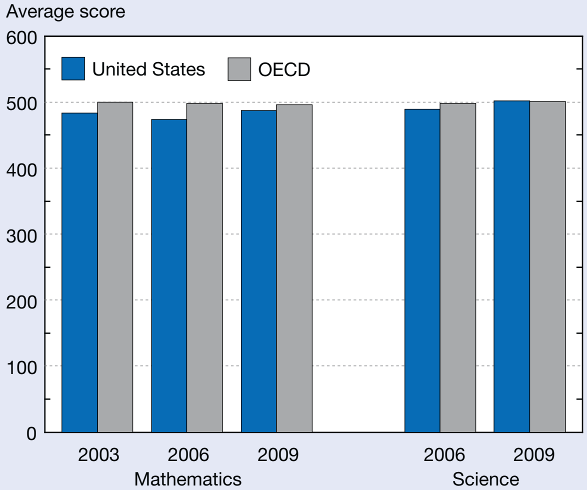
For additional sample questions, see http://www.pisa.oecd.org/dataoecd/47/23/41943106.pdf.

Student Coursetaking in High School Mathematics and Science

Increasing mathematics and science coursetaking is one goal of current education reform efforts.[22] Policymakers are calling for high school students to take more courses in mathematics and science, particularly at the advanced level, to ensure they are adequately prepared for college and careers and to keep the United States competitive in the global marketplace (NSB 2010a; President's Council of Advisors on Science and Technology 2010). Strategies to increase mathematics and science coursetaking have focused on raising high school graduation requirements to include more mathematics and science courses, creating core academic standards to ensure that these courses are sufficiently rigorous, and encouraging students to take more rigorous mathematics and science courses.

This section provides indicators of mathematics and science coursetaking in the United States. The section begins with contextual information about programmatic efforts to increase

Figure 1-4
Average PISA mathematics and science literacy scores of 15-year-old students in the United States and OECD countries: 2003, 2006, and 2009



OECD = Organisation for Economic Co-operation and Development; PISA = Programme for International Student Assessment

NOTE: The average scores for OECD countries cannot be compared across years because the number of OECD countries participating in PISA assessments changed over time.

SOURCES: Lemke M, Sen A, Pahlke E, Partelow L, Miller D, Williams T, Kastberg D, Jocelyn L, *International Outcomes of Learning in Mathematics Literacy and Problem Solving: PISA 2003 Results From the U.S. Perspective,* National Center for Education Statistics (NCES), 2005-003 (2004); Baldi S, Jin Y, Skemer M, Green PJ, Herget D, *Highlights From PISA 2006: Performance of U.S. 15-Year-Old Students in Science and Mathematics Literacy in an International Context,* National Center for Education Statistics, NCES 2008-016 (2007); Fleischman HL, Hopstock PJ, Pelczar MP, Shelley BE, *Highlights From PISA 2009: Performance of U.S. 15-Year-Old Students in Reading, Mathematics, and Science Literacy in an International Context,* National Center for Education Statistics, NCES 2011-004 (2010).

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mathematics and science coursetaking and to standardize the quality of these courses. The section next examines various indicators of mathematics and science coursetaking by recent high school graduates in the United States, including trends in *overall* mathematics and science credits completed by high school graduates, the extent to which students take *advanced* mathematics and science courses, enrollment in algebra I before high school, and differences in these indicators among various demographic groups.

The primary data source for this section is the NAEP High School Transcript Study (HSTS). Conducted every 4 to 6 years since 1990, HSTS analyzes transcripts from a nationally representative sample of U.S. high school graduates. Results from the 2009 NAEP HSTS are compared to the results from the 2005, 2000, and 1990 studies. Because the HSTS has been conducted periodically for more than two decades, the data illuminate trends in coursetaking. In addition to course credits earned, HSTS collects student information such as gender and race/ethnicity, allowing comparisons of coursetaking, credits earned, and achievement across demographic groups.

High School Graduation Requirements and Curriculum Standards

The American Diploma Project (ADP) Network includes government and education leaders from 35 states. It seeks to improve student achievement by aligning high school academic content standards with the demands of college and careers and by requiring all graduating students to have completed a college-and-career-ready curriculum (Achieve, Inc. 2011). ADP also encourages states and school districts to adopt graduation benchmarks that align high school coursework with the expectations of colleges and employers. These benchmarks specify that students should take at least 3 years of science and 4 years of mathematics to earn a high school diploma and that some of these courses should be at the advanced level. For example, the benchmarks specify that students must complete mathematics courses at least through the level of precalculus and that science courses must include biology, chemistry, and physics. Currently, 20 states and the District of Columbia have adopted these graduation requirements (Achieve, Inc. 2011).

The Council of Chief State School Officers has documented the nationwide trend of rising mathematics and science coursework requirements to earn a high school diploma (table 1-6). In the mid-1980s, the predominant graduation requirement for mathematics and science coursetaking was 2 years in each subject. No state in 1987, for example, required 4 years of mathematics to graduate; by 2006, 6 states required 4 years of mathematics, and that number doubled to 12 states in 2008. The number of states requiring 4 years of science to graduate jumped from 0 in 1987 to 1 in 2006 and 4 in 2008. More than half of states (27) required 3 years of science to graduate in 2008, a substantial increase from the 3 states with that requirement in 1987.

While graduation requirements for mathematics and science coursetaking show an upward trend, a recent ACT report (2010) found that nearly half of high school seniors planning to attend college had not completed the advanced courses necessary to enroll in credit-bearing college courses. Thus, ADP continues its efforts not only to increase the *number* of mathematics and science courses required to graduate, but also to have states specify that some of these courses be at an *advanced* level.

A complementary reform effort, the Common Core State Standards Initiative, focuses on the content of the courses that students take rather than the number or level of courses. Its goal is to ensure that academic standards across states are similar and that they include the rigorous content and higher order skills necessary to prepare all students for college and careers (see sidebar "Common Core State Standards").

Table 1-6
State graduation requirements for mathematics and science, by number of years required: Selected years, 1987–2008
(Number of states)

State/local standard	Mathematics 1987	Mathematics 1996	Mathematics 2006	Mathematics 2008	Science 1987	Science 1996	Science 2006	Science 2008
Local decision[a]	6	7	6	6	6	7	6	6
1–2 years[b]	33	26	12	6	40	33	16	13
3 years	10	15	26	25	3	8	27	27
4 years	0	2	6	12	0	2	1	4

[a]Local decision means that graduation requirements are set by local districts and may vary within a state.
[b]In 2008, all states with statewide requirements required ≥2 years of mathematics courses; only one state (Illinois) required 1 year of science.

NOTES: Data include Washington, DC. Column totals do not add to 51 because certain states did not participate in Council of Chief State School Officers (CCSSO) survey that year or used a different credit reporting system.

SOURCES: CCSSO, *Key State Education Policies on PK-12 Education: 2008* (2009); Snyder TD, *Digest of Education Statistics 1988,* NCES 88-600 (1988); and Snyder TD, *Digest of Education Statistics 1998,* NCES 1999-036 (1999).

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Common Core State Standards

To ensure that students graduate from high school adequately prepared for college and employment, a group of 48 states, led by the National Governors Association's Center for Best Practices and the Council of Chief State School Officers, has developed the Common Core State Standards Initiative (CCSSI) (NGA 2009). The standards outline a body of knowledge and skills students must master at each grade level to graduate from high school ready for college and career in the 21st century. The standards clarify what students are expected to learn in each grade, permit cross-state comparisons, and seek to improve student achievement by increasing the rigor of courses required to meet the standards (Fine 2010).

To date, CCSSI has sponsored development of standards for English language arts (ELA) and mathematics for grades K−12. (Detailed information on the ELA and mathematics standards is available on the CCSSI website at http://www.corestandards.org/read-the-standards/.) The National Research Council is currently working on a framework for new national science standards for grades K−12 that states will have the opportunity to include in their common core standards when the standards become available in 2012 (Achieve, Inc. 2011).

Of the 48 states participating in CCSSI (Texas and Alaska do not participate), 44 states and the District of Columbia had adopted the standards by the end of 2010 (Gewertz 2010). States adopted the standards for a variety of reasons, including their rigor, the opportunity for cross-state comparisons, and increased chances of securing Race to the Top funds (EdSource 2010; Kober and Rentner 2011; The Opportunity Equation 2011). According to a recent survey, a majority of the states adopting the standards plan to develop new assessments, curriculum materials, instructional practices, teacher induction and professional development programs, and teacher evaluation systems based on the standards (Kober and Rentner 2011).

Mathematics and Science Coursetaking in High School

HSTS distinguishes between two levels of mathematics and science courses: general and advanced.[23] General-level courses include introductory content needed for more advanced courses. General mathematics includes courses such as basic mathematics, prealgebra, algebra I, and geometry. General science courses include science survey, introduction to physics, and biology 1.

Advanced courses include higher level content and are sometimes the second-year courses in a subject.[24] For example, advanced mathematics courses include algebra II, precalculus/analysis, trigonometry, statistics and probability, and calculus. Advanced science courses include advanced biology, chemistry, and physics. (Engineering is considered an advanced course and often is grouped with advanced science courses for analysis, as it is in this section.)

Researchers and policymakers suggest that it is not enough simply to require students to earn more credits in mathematics and science; students also need to earn credits in *advanced* courses if goals for improved mathematics and science education and outcomes are to be met. Advanced mathematics and science coursetaking is a strong predictor of students' educational success. For example, students who take advanced mathematics and science courses in high school are more likely to earn higher scores on academic assessments, enroll in college, pursue mathematics and science majors in college, and complete a bachelor's degree (Bozick and Lauff 2007; Chen 2009; NCES 2010, 2011; Nord et al. 2011).

Trends in Total Science and Mathematics Credits Earned

Data from HSTS show that the graduating class of 2009 continued the upward trend of having earned more *total* credits in mathematics and science.[25] The average number of credits earned for all mathematics courses was 3.9 in 2009, up from 3.2 in 1990 (figure 1-5) The average number of credits earned for all science courses was 3.5 in 2009, up from 2.8 in 1990.

Trends in Advanced Science and Mathematics Credits Earned

HSTS data also show that U.S. high school students are taking increasing numbers of *advanced* mathematics and science courses. The average number of credits earned by high school graduates in advanced mathematics courses increased from 0.9 in 1990 to 1.7 in 2009 (figure 1-5). Graduates in 1990 earned an average of 1.1 credits in advanced science and engineering courses, compared with 1.9 credits in 2009.

Credits earned for advanced mathematics courses. From 1990 to 2009, the percentages of students taking advanced mathematics courses increased substantially (figure 1-6). For example, 76% of all graduates earned a credit for algebra II in 2009 compared to 53% of all graduates in 1990. The percentage of students taking and completing precalculus/analysis has more than doubled since 1990: 35% in 2009 compared to 14% in 1990.[26] The overall percentage of students earning credits in calculus (17%) and AP/IB mathematics courses (15%) in 2009 has increased since 1990, when 7% of students took calculus and 4% took an AP/IB course.

One reason students have been able to increase the number of advanced mathematics courses taken in high school is that in recent years more of them have been taking algebra I before high school (Nord et al. 2011) (see sidebar "Taking Algebra I Before High School").

Credits earned for advanced science courses. Many more students took advanced science courses in 2009 as well (figure 1-7).[27] The percentage who earned an advanced chemistry credit increased from 45% in 1990 to 70% in 2009, and comparable increases for advanced biology (from 28% to 45%) and physics (from 24% to 39%) were also large. The percentage of students taking advanced environmental/earth science and AP/IB science courses showed similar upward trends, though fewer students took these courses. Fourteen percent of students took an AP/IB science course in 2009, compared to 11% in 2005.[28]

Compared with advanced mathematics and science, fewer students earned credits in engineering: 3% of 2009 graduates had taken engineering in high school, up from 1.5% in 2005.

Taking Algebra I Before High School

Algebra I is considered a "gateway" course leading to more advanced coursetaking in mathematics and science and to higher levels of achievement (Loveless 2008). An increasing number of educators and researchers are calling for more students to take algebra I before high school (Ma and Wilkins 2007; Matthews and Farmer 2008; National Mathematics Advisory Panel 2008).

High school transcripts indicate credits earned for high school courses taken before ninth grade. According to HSTS data, 26% of high school graduates took algebra I before high school in 2009, up from 20% in 2005 (table 1-A). Percentages of both male and female graduates taking algebra before high school increased, though females (27%) slightly outpaced males (25%) in 2009. Upward trends occurred in all racial/ethnic groups as well, with black, Hispanic, and white graduates posting increases of 4, 7, and 6 percentage points, respectively. Asian/Pacific Islander students outpaced their peers by increasing their rates of completing algebra 1 before high school from 30% in 2005 to 48% in 2009.

HSTS identifies three curriculum levels based on the types of courses students take: standard, midlevel, and rigorous. A rigorous curriculum includes 4 years of mathematics including up to at least precalculus and 3 years of science, which must include biology, chemistry, and physics. HSTS data show that nearly two-thirds of graduates who completed a rigorous high school curriculum took algebra I before high school (Nord et al. 2011).

Table 1-A
High school graduates completing first-year algebra before high school, by student characteristic: 2005 and 2009
(Percent)

Student characteristic	2005	2009
All students	20	26
Sex		
Male	20	25
Female	20	27
Race/ethnicity		
White, non-Hispanic	23	29
Black, non-Hispanic	8	12
Hispanic	10	17
Asian/Pacific Islander	30	48

NOTE: American Indian/Alaska Native students are included in "all students" but are not shown separately due to small sample sizes.

SOURCE: Nord C, Roey S, Perkins R, Lyons M, Lemanski N, Brown J, Schuknecht J, America's *High School Graduates: Results of the 2009 NAEP High School Transcript Study,* NCES 2011-462 (2011).

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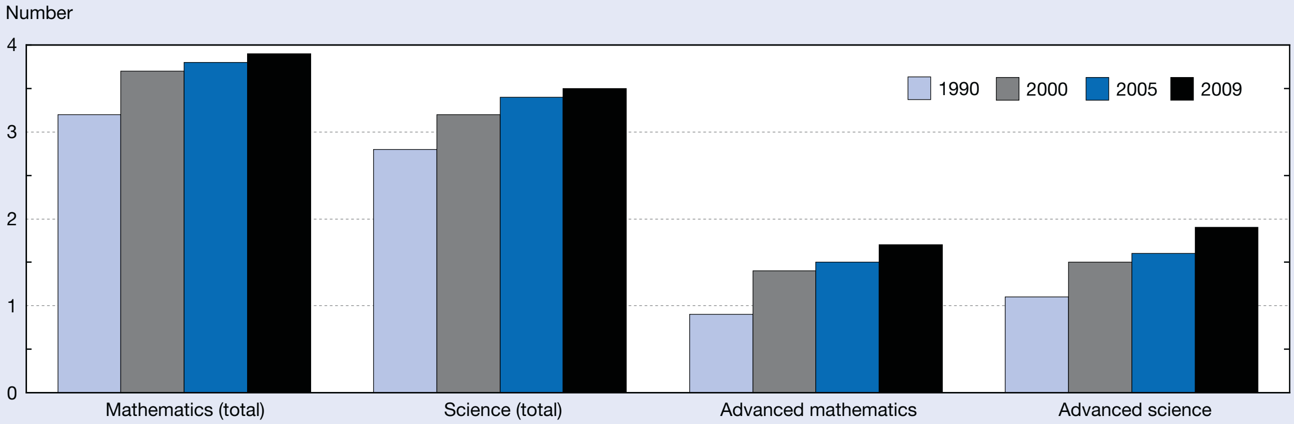
Figure 1-5
Average total and advanced mathematics and science credits earned by high school graduates: Selected years, 1990–2009



AP = Advanced Placement; IB = International Baccalaureate

NOTES: “Advanced mathematics” courses include algebra II, trigonometry, statistics/probability, precalculus/analysis, calculus, and any AP/IB mathematics courses. “Advanced science” courses include advanced biology, chemistry, physics, advanced environmental/earth science, engineering, and any AP/IB science courses.

SOURCES: Nord C, Roey S, Perkins R, Lyons M, Lemanski N, Brown J, Schuknecht J, *America’s High School Graduates: Results of the 2009 NAEP High School Transcript Study,* NCES 2011-462 (2011); National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of National Assessment of Educational Progress 1990, 2000, 2005, and 2009 High School Transcript Studies, National Center for Education Statistics. See appendix table 1-7.

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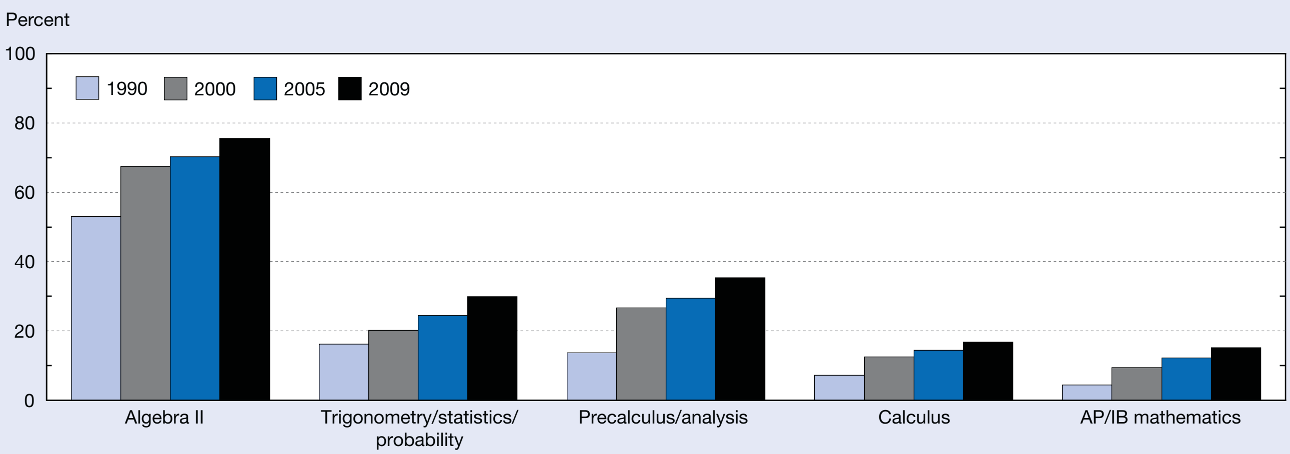
Figure 1-6
High school graduates completing various advanced mathematics courses, by subject: Selected years, 1990–2009



AP = Advanced Placement; IB = International Baccalaureate

NOTE: AP/IB courses are shown separately here but also could be included in other bars. For example, calculus includes any calculus course, including AP calculus.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of National Assessment of Educational Progress 1990, 2000, 2005, and 2009 High School Transcript Studies, National Center for Education Statistics. See appendix table 1-8.

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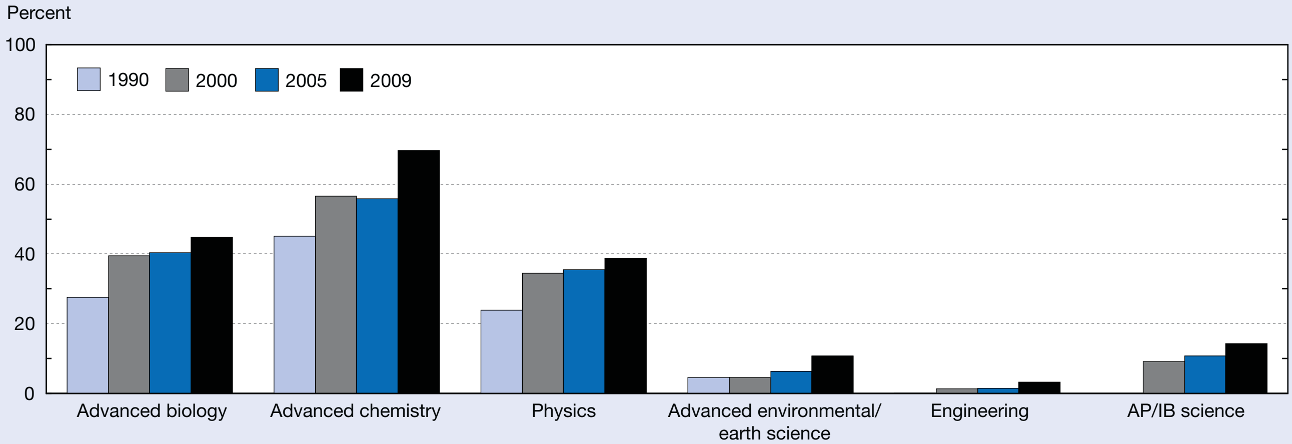
Figure 1-7
High school graduates completing various advanced science and engineering courses, by subject: Selected years, 1990–2009



AP = Advanced Placement; IB = International Baccalaureate

NOTES: “Advanced biology” includes AP/IB biology, physiology, anatomy, and genetics. “Advanced environmental and earth sciences” includes AP/IB environmental sciences, college preparatory earth science, and various geology courses. AP/IB courses are shown separately here but also included in other bars. For example, “Physics” includes any advanced physics course, including AP physics, and “Chemistry” includes any advanced chemistry course, including AP chemistry.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of National Assessment of Educational Progress 1990, 2000, 2005, and 2009 High School Transcript Studies, National Center for Education Statistics. See appendix table 1-9.

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Demographic Differences in Advanced Mathematics and Science Credits Earned

Although mathematics and science coursetaking has increased for all demographic groups, differences among these groups have persisted. White students are more likely to earn advanced credits than black or Hispanic students. Asian/Pacific Islander students outpace other groups of students in terms of credits earned and percentages taking advanced courses.

Credits earned in advanced courses. In 2009, females and males earned approximately equal credits in advanced mathematics—an average of 1.7 credits (appendix table 1-7). Among racial/ethnic groups, Asian/Pacific Islander students earned the most credits in advanced mathematics, an average of 2.4 credits in 2009. Hispanics (1.3) and blacks (1.4) earned the fewest credits in advanced mathematics. White students earned substantially more credits (1.8) than black or Hispanic students, but significantly fewer than Asian/Pacific Islander students.

In 2009, females earned an average of 1.9 advanced science and engineering credits, compared to 1.8 credits for males. Among major racial/ethnic groups, Asian/Pacific Islander students earned the highest number of credits in advanced science and engineering (2.8). Hispanic and black students earned 1.5 and 1.6 credits, respectively, in these subjects. White students earned more credits (2.0 credits in advanced science and engineering) than black or Hispanic students, but fewer than Asian/Pacific Islanders.

Percentage taking advanced courses. The percentage of females taking precalculus/analysis (37%) was higher than that of males (34%), as was the percentage of females taking algebra II (78% compared to 74%) (appendix table 1-8). An equal percentage of males and females (17%) took calculus. Asian/Pacific Islander students outpaced all other groups in taking advanced mathematics in 2009. The most striking disparities occurred in AP/IB mathematics coursetaking, with Asian/Pacific Islander students (42%) taking these courses at rates approximately 6 times that of black students (7%), 4 times that of Hispanic students (9%), and 2.5 times that of white students (16%).

Gender differences in advanced science coursetaking varied by subject (appendix table 1-9). Whereas more females than males took advanced biology (50% versus 39%), males took physics at higher rates than females (42% versus 36%). Males were 6 times more likely to have taken engineering (6% versus 1%). Asian/Pacific Islander students took advanced science and engineering courses at rates higher than those of other ethnic groups.

Teachers of Mathematics and Science

Among the many factors that influence student learning, teacher quality is crucial. To ensure that all classrooms are led by high-quality teachers, NCLB mandated that schools and districts hire only highly qualified teachers, defining “highly qualified” as having state certification, a minimum of a bachelor’s degree, and demonstrated subject area competence. Teaching quality has remained in the national spotlight. The Race to the Top program, a component of the American Recovery and Reinvestment Act of 2009, called for applications from states to compete for more than $4 billion for education innovation and reform, including recruitment, professional development, compensation, and retention of effective teachers.[29] Salaries, working conditions, and opportunities for professional development contribute to keeping teachers in the profession and the best teachers in the classroom (Berry, Smylie, and Fuller 2008; Brill and McCartney 2008; Hanushek and Rivkin 2007; Ingersoll and May 2010).

This section presents indicators of public school mathematics and science teachers' preparation, experience, professional development, salaries, and working conditions. It focuses on middle and high school teachers, as mathematics and science teachers are more common and more easily identified at these levels than at the elementary level.[30] The primary data source is the 2007–08 SASS; comparable data from earlier SASS collections are also used to examine changes over time. The section refers to 2007 and 2003 to indicate the academic years 2007–08 and 2003–04. When possible, measures are analyzed separately for schools with differing concentrations of minority and low-income students.[31]

To provide context, U.S. public school teachers numbered about 3.4 million in 2007 (appendix table 1-10), a 14% increase over the approximately 3.0 million teachers employed in 1999 (Gruber et al. 2002). Approximately 419,000 taught mathematics or science at public middle and high schools, accounting for 12% of the public school teaching force nationwide.

Characteristics of High-Quality Teachers

The effects of good teachers on student achievement have been well documented (Boyd et al. 2008; Clotfelter, Ladd, and Vigdor 2007; Goe 2008; Guarino, Santibanez, and Daley 2006; Harris and Sass 2007), but the specific teacher characteristics that contribute to student success are less clear (see sidebar "Measuring Teaching Quality"). Some studies have cast doubt on whether commonly measured indicators, such as teachers' licensure scores or the selectivity of their undergraduate institutions, are related to teaching effectiveness (Boyd et al. 2006; Buddin and Zamarro 2009a, 2009b; Hanushek and Rivkin 2006). This section reports on indicators such as public school mathematics and science teachers' educational attainment, professional certification, participation in practice teaching, self-assessment of preparation, and years of experience. Although these are not the only characteristics that contribute to teacher effectiveness, they are more easily measured than such other characteristics as teachers' abilities to motivate students, manage the classroom, maximize instruction time, and diagnose and overcome students' learning difficulties.

Highest Degree Attained

Virtually all mathematics and science teachers at public middle and high schools held at least a bachelor's degree in 2007, and more than half had earned an advanced degree (e.g., master's degree, education specialist, certificate of advanced graduate studies, doctorate, professional degree) (appendix table 1-11). The proportion of mathematics and science teachers with a master's or higher degree has increased since 2003 (from 48% to 54% for mathematics teachers and from 52% to 58% for science teachers).

Teachers with advanced degrees are not evenly distributed across schools, however. Proportionately more mathematics and science teachers in low-poverty and low-minority schools held master's degrees than did their peers in high-poverty and high-minority schools.[32] For example, in 2007–08, 61% of science teachers in low-poverty schools had earned a master's degree, compared with 41% of those in high-poverty schools.

Certification and Entry into the Profession

The traditional path to becoming a teacher begins in an undergraduate education program, where future teachers earn a bachelor's or master's degree and full teaching certification prior to beginning to teach. In recent years, a growing proportion of new teachers have entered the profession through an alternative pathway, usually a program that recruits college graduates from other fields or mid-career professionals in non-teaching careers. These teachers often begin to teach with probationary or temporary certification while they work toward regular certification during the first few years of their teaching careers.[33] Regardless of their pathway into the profession, all public school teachers must have some type of state certification to teach.

State Certification. Teacher certification refers to a license required by the state of all practicing teachers; requirements vary by state but typically include completing a bachelor's degree, completing a period of practice teaching, and passing a formal test[34] (Editorial Projects in Education Research Center 2010). Most states require high school teachers of mathematics and science to have a degree or certificate in their subject area. At the middle school level, some states allow general education preparation and others require subject area preparation for mathematics and science teachers (Greenberg and Walsh 2008). Differences in state standards and requirements for certification complicate measurement of the impact of teachers' credentials on student outcomes; nevertheless, some studies suggest that holding a regular or advanced certification is associated with student achievement (Clotfelter, Ladd, and Vigdor 2007; Easton-Brooks and Davis 2009; Klecker 2008; Subedi, Swan, and Hynes 2010).

In 2007, 87% of public middle and high school mathematics and science teachers were fully certified (i.e., held regular or advanced state certification) (table 1-7). The percentage of science teachers with full certification has increased by 4

Measuring Teaching Quality

No research has conclusively identified the most effective teachers or the factors that contribute to their success, but efforts to improve measures of teaching quality have proliferated in recent years. For example, 21 states and over 100 teacher preparation programs have joined the Teacher Performance Assessment Consortium (TPAC) to develop a teacher evaluation instrument. The evaluation will be based on assessments embedded in teachers' preparatory coursework and on documentation of teaching and learning during multi-day lessons.

Another effort has focused on establishing a composite indicator for effective teaching by measuring student gains on test scores, quality of teaching practice, teachers' pedagogical content knowledge, student perceptions of the classroom environment, and teachers' perceptions of working conditions and instructional support at their schools (Measures of Effective Teaching 2010). Through the Measures of Effective Teaching project, researchers have analyzed data in large school districts nationwide to identify effective teachers and teaching practices. Data collection began in the 2009−10 academic year and continued in 2010−11.

A similar effort focused on mathematics teaching quality is underway at the National Center for Teacher Effectiveness, which seeks to identify practices and characteristics that distinguish effective mathematics teachers and to develop practical instruments and training tools for school districts. The center's core project, Developing Measures of Effective Mathematics Teaching, will combine measures of teacher characteristics, practice, and content knowledge and measures of student engagement and learning to build a composite measure of teaching effectiveness in mathematics. Data collection in approximately 50 schools and 200 classrooms began in 2010 and will continue through 2013.

These projects are among the largest efforts to incorporate gains in student test scores into the measurement of quality, but they are not the first. Several researchers have sought to develop so called "value-added" models that link teacher effectiveness to student gains in achievement test scores (Hanushek and Rivkin 2010; Hanushek et al. 2005). These models do not directly measure variation in teaching practices; rather, they compare test score gains of students with similar background characteristics and initial scores within the same school and attribute students' differences in progress to their teachers (Baker et al. 2010). Although some studies have validated the value-added approach (Jacob and Lefgren 2008; Kane et al. 2010; Kane and Staiger 2008), researchers have raised concerns about nonrandom assignment of students to teachers within a school; the use of standardized tests that do not adequately measure students' knowledge, skills, and progress; and family support or other factors outside of school that contribute to students' achievement (Baker et al. 2010; Hanushek and Rivkin 2010; Rothstein 2008).

Despite these concerns, there seems to be consensus that these models can contribute to current efforts to evaluate teaching when used along with other observable measures. However, researchers have not yet arrived at a comprehensive model for measuring teaching quality.

More information on the Teacher Performance Assessment Consortium is available at http://aacte.org/index.php?/Programs/Teacher-Performance-Assessment-Consortium-TPAC/teacher-performance-assessment-consortium.html. More information about the Measures of Effective Teaching project is available at http://www.metproject.org/. More information about the Developing Measures of Effective Mathematics Teaching project is available at http://www.gse.harvard.edu/ncte/projects/project1/default.php.

Table 1-7
Public middle and high school teachers with regular or advanced certification, by teaching field: Academic years 2003–04 and 2007–08
(Percent)

Teaching field	Academic year 2003–04	Academic year 2007–08
Mathematics	85.1	87.0
Science	82.8	87.3
Other	86.6	88.1

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 2003–04 and 2007–08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-12.

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percentage points since 2003 (from 83% to 87%), and has increased at a faster pace at low-minority schools (from 86% to 93%) (appendix table 1-12).

Fully certified mathematics and science teachers were more prevalent in low-minority schools (92% of mathematics and 93% of science teachers) than in high-minority schools (84% of mathematics and 83% of science teachers) (appendix table 1-12). Fully certified science teachers were also more prevalent in low-poverty schools (89%) than in high-poverty schools (81%). The percentage of fully certified mathematics and science teachers at high-minority and both high- and low-poverty schools has not changed significantly since 2003.

Alternative Entry into the Teaching Profession. Rather than completing traditional undergraduate programs in education, some teachers enter teaching through alternative programs such as Teach for America, The New Teacher Project, and other programs administered by states, districts, universities, and other organizations to expedite the transition of nonteachers into teaching. Although these programs have expanded in recent years,[35] researchers have observed few systematic differences in the training received by aspiring teachers in traditional versus alternative pathways (Humphrey, Weschler, and Hough 2008; NRC 2010; Zeichner and Conklin 2005).[36] Much of the formal training for teachers in both traditional and alternative programs takes place in university schools of education (Walsh and Jacobs 2007); according to SASS, however, a significantly smaller proportion of alternative-pathway teachers participated in practice teaching prior to beginning teaching (see "Practice Teaching" section). Some characteristics of teachers who enter through traditional and alternative programs, such as the selectivity of their undergraduate institutions or the likelihood of holding advanced degrees, are also similar (Cohen-Vogel and Smith 2007). Research has found mixed or no effects of teachers' pathway into the profession on students' achievement (Constantine et al. 2009; Boyd et al. 2006; Zeichner and Conklin 2005).

Some alternative entry programs place recruits in "high-need" schools, generally those with high levels of student poverty and low levels of student achievement. According to its website, the New Teacher Project has placed 43,000 teachers of all subjects in high-need locations since 1997, and Teach for America's annual placement of teachers in high-need schools has grown from about 2,000 to 5,000 between 2005 and 2010 (TFA 2006, 2008, 2009). Although statistics on the number of mathematics and science teachers placed are not available, the New Teacher Project and Teach for America include increasing the supply of teachers in those subject areas among their goals.[37]

In 2007, 19% of all public middle and high school mathematics teachers and 22% of science teachers had entered the profession through an alternative certification program, compared with 16% of teachers in other fields (appendix table 1-13). Teachers who had entered through alternative programs were more concentrated in schools with high rates of minority enrollment and school poverty. For example, 26% of mathematics teachers in schools with the highest poverty levels had entered teaching through an alternative program, compared with 12% of those in schools with the lowest poverty levels. Nationwide, the supply of new mathematics and science teachers may not be sufficient to replace those who retire or leave the profession for other reasons, and teacher shortages in these subjects are not distributed evenly across schools (Ingersoll and Perda 2009). High-poverty schools in urban areas tend to have the highest rates of teacher turnover; resulting shortages may contribute to schools' decision to hire teachers from alternative entry programs.

National Board Certification

Some experienced teachers pursue certification from the National Board for Professional Teaching Standards, a nonprofit organization that evaluates teachers' performance against a set of professional standards and confers certificates indicating superior teaching quality.[38] Applicants must have completed 3 years of teaching and must hold state certification to be eligible. They must then complete 10 assessments reviewed by evaluators in their subject area—requirements that are more rigorous than those for state certification. Assessments include six online exercises, which test content knowledge in specific certificate areas, and four portfolio submissions, including video recordings of classroom practice and examples of student work.

Research on the effects of National Board Certification on student outcomes has generally been inconclusive. An assessment of 11 such studies by the National Academy of Sciences concluded that in any case, such a relationship is not a strong one (Hakel, Koenig, and Elliott 2008). Research in several states has shown that teachers holding this certification are less likely to teach in schools with high proportions of poor, minority, and low-performing students (Goldhaber, Choi, and Cramer 2007; Humphrey, Koppich, and Hough 2005). According to the National Board website, more than 90,000 teachers were National Board Certified as of 2010, a 90% increase since 2005, and 42% teach in schools eligible for Title I, a federal program to provide funds to schools and districts with high percentages of low-income students.[39] About one-quarter of school districts offer pay incentives for teachers who earn National Board Certification (Aritomi and Coopersmith 2009).

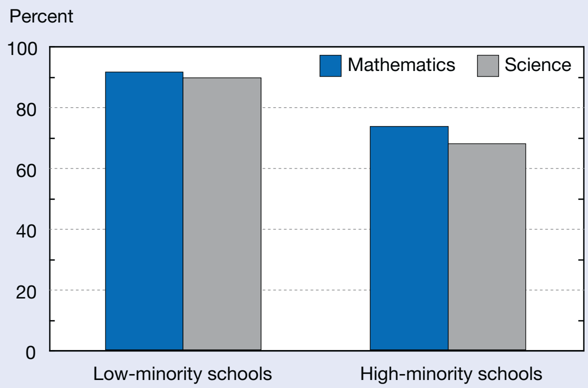
Practice Teaching

Practice teaching (also called student teaching) offers prospective teachers hands-on classroom experience to help them transfer what they learn from coursework into classroom teaching. Practical experience in the classroom affects teaching quality (Boyd et al. 2008),[40] and SASS data support this finding: among teachers with fewer than 5 years of experience (referred to here as "new teachers"), those who had participated in practice teaching were more likely to report feeling well prepared or very well prepared for various aspects of teaching during their first year than did those who had not had practice teaching (appendix table 1-14).

Among new public middle and high school mathematics and science teachers in 2007, about three-quarters had participated in practice teaching (appendix table 1-15). The proportion differed by school composition: 91% of new mathematics and 90% of new science teachers at low-minority schools participated in practice teaching, compared with 73% and 68%, respectively, at high-minority schools (figure 1-8).

The proportion of new mathematics and science teachers who have participated in practice teaching has declined during recent years. Seventy-five percent of new mathematics and 72% of new science teachers reported participation in practice

Figure 1-8
Participation of new public middle and high school teachers in practice teaching, by teaching field and minority enrollment: Academic year 2007–08



NOTES: "New teachers" refers to those with fewer than 5 years of teaching experience. Minority students constitute 0%–5% of the student population at low-minority schools and more than 45% of the population at high-minority schools.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of 2007–08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-15.

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teaching in 2007, compared with 79% and 75%, respectively, in 2003 (appendix table 1-15). The decline may be due to the increasing number of teachers who enter the profession through alternative programs and who are significantly less likely to have participated in practice teaching. In 2007, 43% of mathematics teachers and 51% of science teachers who entered the profession through an alternative program had participated in practice teaching, lower than the 94% of mathematics and 92% of science teachers who entered teaching the traditional way (appendix table 1-16). Thirty-nine states require prospective teachers in traditional preparation programs to participate in practice teaching, while six require teachers in alternative programs to practice teach (Editorial Projects in Education Research Center 2010).

Self-Assessment of Preparedness

New middle and high school teachers (i.e., those with fewer than 5 years of experience) generally felt well prepared to perform various tasks during their first year of teaching, and science teachers in particular have seen improvements in feeling prepared (appendix table 1-17). In 2007, 88% of new mathematics teachers and 89% of new science teachers felt prepared to teach their subject matter. Among new science teachers, this represents an increase since 2003, when 79% felt prepared to teach the subject matter. More new science teachers also felt prepared to use computers in instruction: 75% reported feeling prepared in 2007, compared with 62% in 2003.

New teachers' assessments of their preparation varied with the characteristics of their schools. For example, 99% of new mathematics teachers and 95% of new science teachers in low-minority schools felt prepared to teach their subject matter, compared with 84% and 85% of their peers in high-minority schools (appendix table 1-17).

Experience

Teachers generally are more effective in helping students learn as they gain years of experience, particularly during their first few years (Boyd et al. 2006; Clotfelter, Ladd, and Vigdor 2007; Harris and Sass 2008; Rice 2010). In 2007, about one-fifth of public middle and high school mathematics and science teachers were novices with 3 or fewer years of experience (appendix table 1-18). Proportionally more mathematics teachers at high-minority schools were novice teachers than at low-minority schools (22% versus 13%). Similarly, novice science teachers were more prevalent in high-poverty schools than in low-poverty schools (25% versus 15%).

School Factors Contributing to Teachers' Effectiveness

Teachers bring a variety of knowledge, skills, and experience into their classrooms, but conditions in their schools and districts also influence their effectiveness in promoting student outcomes and their decisions about remaining in the profession. This section presents indicators of district and school attributes that affect teachers' success, including the assignment of teachers to subjects, initial and ongoing professional development, salaries, and working conditions.

In-Field Teaching

Over the past decade, few issues related to teaching quality have received more attention than in-field teaching assignment in middle and high schools (Almy and Theokas 2010; Dee and Cohodes 2008; Peske and Haycock 2006). NCLB mandates that all students have teachers who demonstrate competence in subject knowledge and teaching. NCLB does not provide specific guidance or criteria for adequate preparation to teach mathematics and science, however, leaving that task to states.

To determine whether teachers have subject-specific preparation for the fields they teach, recent research focused on matching teachers' formal preparation (as indicated by degree major and certification field) with their teaching field (Hill and Gruber 2011; McGrath, Holt, and Seastrom 2005; Morton et al. 2008). Following this line of research, the National Science Board (2010b) distinguished four levels of formal preparation for teaching mathematics and science at the middle and high school levels.[41] In order of decreasing rigor of preparation, they are as follows:

- *In field:* Mathematics teachers with a degree and/or full certification in mathematics or mathematics education. Science teachers with a degree and/or full certification in science or science education.

- *Related field:* Mathematics teachers with a degree and/or full certification in a field related to mathematics (e.g., science, science education, computer sciences, engineering). Science teachers with a degree and/or full certification in a field related to their teaching field (e.g., high school biology teachers with a degree and/or full certification in chemistry). This category is omitted for middle school science teachers because science teachers at this level are usually not distinguished by specific science fields such as physics, chemistry, or biology.
- *General preparation:* Mathematics and science teachers with a degree and/or full certification in general elementary, middle, or secondary education.
- *Other:* Mathematics and science teachers without a degree or certification in their teaching field, a related field, or general elementary, middle, or secondary education.

In-field mathematics teachers in public middle schools increased from 53% in 2003 to 64% in 2007 (table 1-8). Seventy percent of science teachers in public middle schools were teaching in field in 2007, not a significant increase over 67% in 2003. In both years, between 27% and 38% of middle school mathematics and science teachers were teaching their subject with general education preparation.

The level of in-field mathematics and science teachers in high schools did not change between 2003 and 2007. In both years, large majorities of high school mathematics teachers (87% in 2003 and 88% in 2007), biology/life science teachers (92% in 2003 and 93% in 2007), and physical science teachers (78% in 2003 and 82% in 2007) taught in field. Relatively few (3% or lower) mathematics and science teachers in high schools had general education preparation.

In-field teachers were more likely in low-minority and low-poverty schools than in their high-minority and high-poverty counterparts (appendix table 1-19). In 2007, for example, 95% of high school mathematics teachers in low-minority schools were teaching in field, compared with 83% in high-minority schools, and 94% of high school mathematics teachers in low-poverty schools were teaching in field, compared with 81% in high-poverty schools.

In-field mathematics teaching became somewhat more common at high-poverty and high-minority middle schools between 2003 and 2007; for example, the rate of in-field mathematics teachers increased from 47% to 65% at high-poverty middle schools and from 51% to 61% at high-minority middle schools.

Professional Development for Mathematics and Science Teachers

Professional development enables teachers to update their knowledge, sharpen their skills, and acquire new teaching techniques, all of which may enhance the quality of teaching and learning (Davis, Petish, and Smithey 2006; Richardson and Placier 2001). Research indicates that professional development can have measurable effects on student performance; an analysis examining outcomes across 16 studies of professional development for mathematics and science teachers found that professional development had statistically significant effects on student performance in mathematics (CCSSO 2009).[42]

New Teacher Induction and Support. Professional development often begins during a teachers' first year in the classroom. Without sufficient support and guidance, teachers in their first and second years may struggle, become less committed to teaching, and leave the profession altogether (Smith and Ingersoll 2004; Smith and Rowley 2005). Teacher induction programs at the school, local, or state level are designed to help teachers in their first 2 years improve their professional practice, deepen their understanding of teaching, and prevent early attrition (Britton et al. 2003; Fulton, Yoon, and Lee 2005; Smith and Ingersoll 2004).

Table 1-8
Preparation of public school mathematics and science teachers for teaching in their field, by school level and teaching field: Academic years 2003–04 and 2007–08
(Percent)

School level/teaching field	Academic year 2003–04				Academic year 2007–08			
	In field	Related field	General education	Other	In field	Related field	General education	Other
Middle school								
Mathematics	53.5	3.9	37.5	5.1	64.3	1.6	30.6	3.4
Science	67.0	na	29.2	3.8	69.6	na	27.0	3.3
High school								
Mathematics	87.4	2.0	3.1	7.5	88.0	1.2	3.4	7.4
Biology/life sciences	91.9	3.6	1.3	3.2	93.2	3.9	0.9	2.0
Physical sciences	78.1	19.6	0.9	1.5	81.6	15.4	1.2	1.8

na = not applicable

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2011) of 2003–04 and 2007–08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-19.

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Participation in new teacher induction programs is becoming more common. Among new public middle and high school teachers with fewer than 5 years of experience in 2007, 79% of mathematics and 73% of science teachers had participated in an induction program during their first year, compared with 71% of mathematics teachers and 68% of science teachers in 2003 (appendix table 1-20). Teacher participation in induction programs was lower in schools with high concentrations of minority and low-income students, but gaps in participation narrowed over time. In 2003, 63% of mathematics teachers in high-minority schools had participated in an induction program, compared with 88% in low-minority schools—a gap of 25 percentage points. In 2007, that gap was 8 percentage points. Gaps narrowed mainly due to increasing percentages of teachers in high-minority and high-poverty schools participating in induction programs. Appendix table 1-21 shows data on other types of support provided to new teachers when they start their careers.

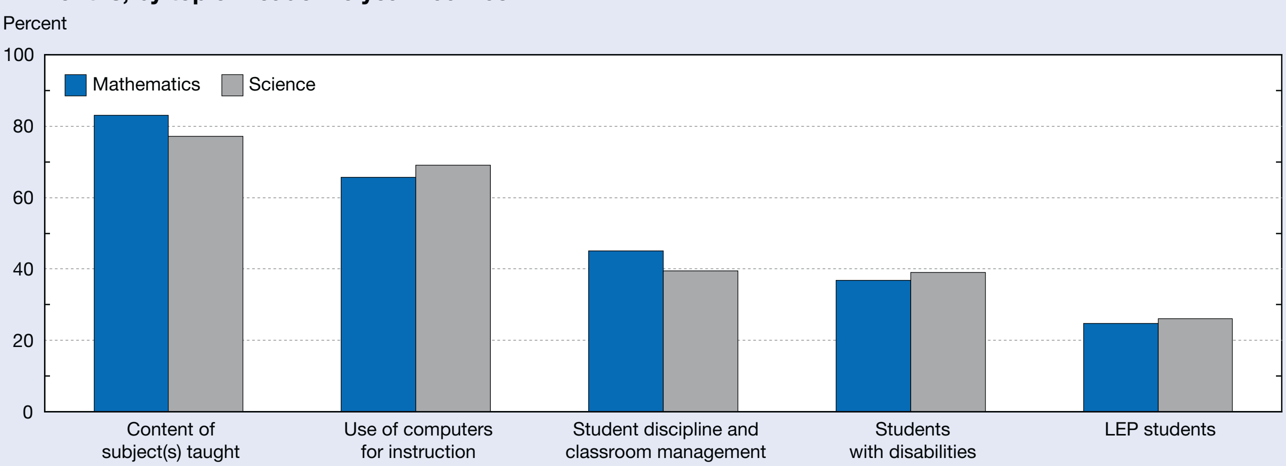
The extent to which these programs help new teachers be more effective is unclear: a recent nationwide study of induction programs at the elementary level found no effects on student achievement for teachers who received a single year of induction, and effects on student achievement for teachers in 2-year induction programs were evident only in teachers' third year of teaching (Glazerman et al. 2010). The study found no relationship between participation in new teacher induction and retention of teachers during their first 4 years. Some research suggests that a subject-matter match between teachers and induction programs improves outcomes for teachers (Luft 2009; Luft et al. 2010), but this question was not examined in the national study.

Ongoing Professional Development. Teachers' professional development does not end after their first few years of teaching. Ongoing training is often mandated by state regulations and delivered by school districts to teachers throughout their careers. In 2007, more than three-quarters of mathematics and science teachers in public middle and high schools received professional development in the content of their teaching subject during the previous 12 months (figure 1-9). Another common focus of teacher professional development programs was the use of computers for instruction: 66% of mathematics and 69% of science teachers received professional development on that topic (appendix table 1-22). Fewer than half received training in classroom discipline or management, teaching students with disabilities, or teaching Limited English Proficient (LEP) students.

The duration of professional development programs is often shorter than what research suggests may be desirable. Although more research is needed to establish a threshold, some studies have suggested 80 hours or more of professional development is necessary to affect teacher practice (Banilower et al. 2006; CCSSO 2009; NSB 2008). Among teachers who received professional development in their subject area, 28% of mathematics and 29% of science teachers received 33 hours or more (figure 1-10).[43]

The three top priority areas for professional development programs identified by mathematics and science teachers at public middle and high schools were student discipline and classroom management, the content of their main subject field, and use of technology in instruction (appendix table 1-23). Teachers in different types of schools had different priorities. For example, 29% of science teachers in high-poverty schools identified student discipline and classroom

Figure 1-9
Participation of public middle and high school teachers in professional development activities during past 12 months, by topic: Academic year 2007–08



LEP = limited English proficiency

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of 2007–08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-22.

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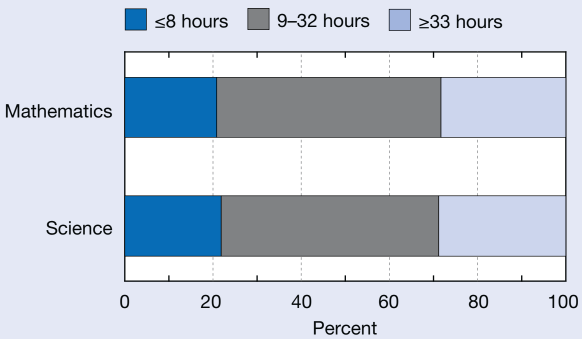
Figure 1-10
Duration of professional development received by public middle and high school teachers in the content of subject(s) taught, by teaching field: Academic year 2007–08



NOTE: Figure includes mathematics and science teachers who received professional development in their subject area during past 12 months.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of 2007–08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-22.

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management as their top priority, compared with 10% of their peers at low-poverty schools.

Teacher Salaries

Financial incentives have been associated with increased teacher recruitment (Berry 2004; Steele, Murnane, and Willet 2009) and retention (Clotfelter et al. 2008; Hanushek, Kain, and Rivkin 2004) (see sidebar "Teacher Attrition"). In 2007, 15% of school districts offered pay incentives in fields of shortage—usually mathematics, science, and special education—and 10% offered rewards for excellence in teaching (Aritomi and Coopersmith 2009). Whether these policies improve overall teaching quality has not been established (Fryer 2011; Hanushek et al. 2005; Hanushek and Rivkin 2007; Rand Corporation 2006; Springer et al. 2010).

Research has indicated that teachers earn less than other professionals with similar levels of education (AFT 2008; Allegretto, Corcoran, and Mishel 2008; Hanushek and Rivkin 2007). The circumstances of employment and the nature of the work differ between teachers and non-teachers, however, and may account for salary differences to some extent. Teachers are more likely than other professionals to work in rural areas, for example, where costs of living and salaries are lower (Taylor 2008). Selecting the appropriate comparison group for teachers also complicates salary comparisons: some research uses figures for most fields requiring a bachelor's degree (AFT 2008), and at least one study suggests that a smaller set of occupations requiring more similar skills may be more appropriate (Milanowski 2008).

In 2007, the average base salary of middle and high school mathematics and science teachers was approximately $50,000, based on teachers' reports in SASS (appendix table 1-24). Salaries varied among schools with different student populations. For example, the average salary of mathematics teachers in public middle and high schools with the lowest rates of minority enrollment was approximately $4,000 less than that of their colleagues in schools with the highest minority enrollment (figure 1-11). High-minority schools tend to be located in urban areas (Keigher 2009), where living expenses are usually higher than in other areas. The pattern is reversed when examining school poverty rates: the average salary for mathematics teachers at schools with the lowest poverty rates was about $7,000 higher than those at schools with the highest rates.

When asked to rate their satisfaction with their salaries, slightly more than half of mathematics teachers reported being satisfied (figure 1-11). Those in low-poverty and low-minority schools were more likely to be satisfied with their salaries than their colleagues in high-poverty and high-minority schools, even though teachers in high-minority schools earned higher base salaries than those in low-minority schools. Patterns were similar among science teachers (appendix table 1-24).

Teacher Perceptions of Working Conditions

Like salaries, working conditions play a role in determining the supply of qualified teachers and influencing their decisions about remaining in the profession. Safe environments, strong administrative leadership, cooperation among teachers, high levels of parent involvement, and sufficient learning resources can improve teacher effectiveness, enhance commitment to their schools, and promote job satisfaction (Berry, Smylie, and Fuller 2008; Brill and McCartney 2008; Guarino, Santibanez, and Daley 2006; Ingersoll and May 2010).

SASS asked teachers whether they agreed with several statements about their school environments and working conditions. Although agreement was not unanimous, large majorities of mathematics and science teachers at public middle and high schools agreed with the following statements regarding their working conditions in 2007: 88% of mathematics and 86% of science teachers reported that the principal knows what kind of school he or she wants and has communicated it to the staff; 85% of mathematics and 82% of science teachers agreed that the necessary materials for teaching were available; and 76% of mathematics and 73% of science teachers agreed that staff were recognized for a job well done (appendix table 1-25).[44]

Responses to some questions differed, however, with the composition of the school's student body. For example, about half of mathematics teachers at high-poverty and high-minority schools reported that students' tardiness and class cutting interfered with teaching, compared with 34–35% of teachers at low-poverty and low-minority schools (figure 1-12). Patterns were similar when mathematics teachers were asked whether student misbehavior interferes with teaching (53% agreed at high-minority schools and 56%

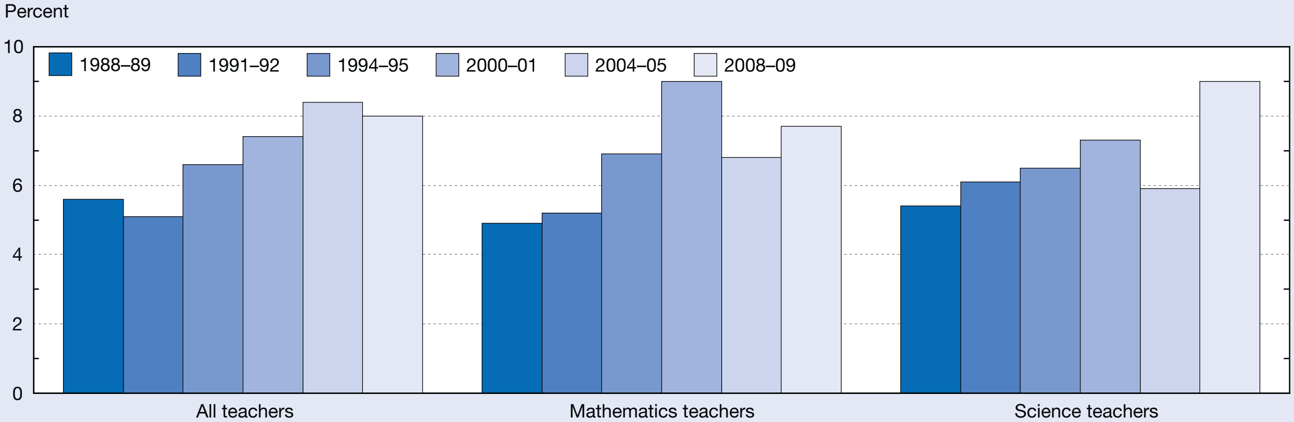
Teacher Attrition

Concerns about K–12 teacher shortages, teaching quality, and the need to retain high-quality instructors in the nation's elementary and secondary schools have led to considerable research on rates of attrition among teachers (Borman and Dowling 2008; Boyd et al. 2009; Ingersoll and Perda 2009; Jalongo and Heider 2006). A recent national study revealed that from 1988 to 2008, 5−9% of public school mathematics and science teachers left the teaching profession each year (figure 1-B) (Keigher and Cross 2010). The annual attrition rates of mathematics and science teachers are not higher than the average for all teachers (8−9% versus 8% in 2008, for example). Mathematics and science teachers who left teaching were also no more likely than other teachers who left to take noneducation jobs (appendix table 1-26).

Another study found large school-to-school differences in mathematics and science turnover (defined as teachers leaving their schools by either moving to another school or leaving teaching altogether) (Ingersoll and May 2010). High-poverty, high-minority, and urban public schools had among the highest mathematics and science teacher turnover rates. Reasons prompting mathematics teachers to leave their schools included lack of individual classroom autonomy, student discipline problems, and the extent to which teachers received useful content-focused professional development. For science teachers, the strongest factors included the maximum potential salary, student discipline problems, and the extent to which teachers received useful content-focused professional development (Ingersoll and May 2010).

More research is needed to establish conclusively links between how teachers enter the profession and attrition, but some has suggested that teachers who enter through alternative programs may be more likely to leave their schools or the profession than traditional-pathway teachers (Boyd et al. 2006; Kane, Rockoff, and Staiger 2006; Smith 2007).

Figure 1-B
One-year attrition rate of public school teachers, by teaching field: Selected academic years, 1988–89 to 2008–09



SOURCES: Whitener SD, Gruber KJ, Lynch H, Tingos K, Perona M, Fondelier S, *Characteristics of Stayers, Movers, and Leavers: Results From the Teacher Follow-up Survey: 1994–95,* National Center for Education Statistics (NCES), NCES 97-450 (1997); Luekens MT, Lyter DM, Fox EE, *Teacher Attrition and Mobility: Results from the Teacher Follow-up Survey,* 2000–01, NCES 2004-301 (2004); Marvel J, Lyter DM, Peltola P, Strizek GA, Morton BA, *Teacher Attrition and Mobility: Results from the 2004–05 Teacher Follow-up Survey,* NCES 2007-307 (2006); Keigher A, *Teacher Attrition and Mobility: Results From the 2008–09 Teacher Follow-up Survey,* NCES 2010-353 (2010).

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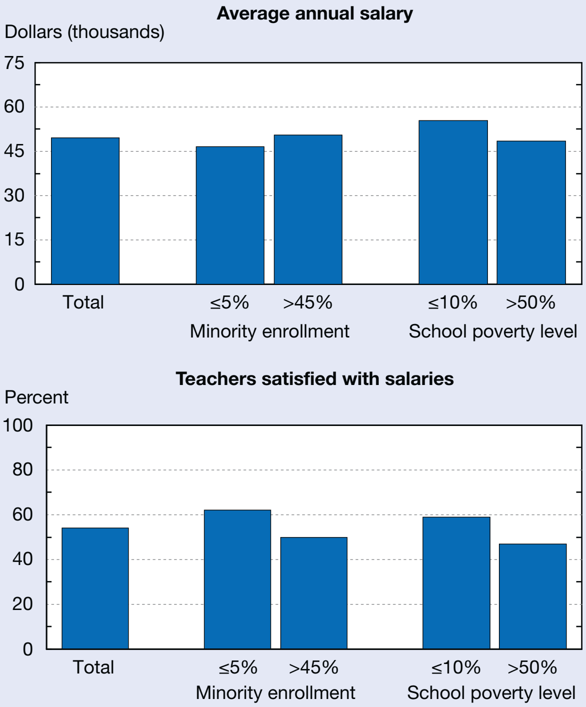
agreed at high-poverty schools whereas 34% agreed at low-minority schools and 35% agreed at low-poverty schools).

Teacher perceptions about certain problems in their schools improved slightly between 2003 and 2007. The percentage of mathematics and science teachers at middle and high schools reporting student apathy and students coming to school unprepared to learn as serious problems declined from 2003 to 2007. For example, 28% of mathematics teachers in 2007, compared with 31% in 2003, identified student apathy as a serious problem at their schools (appendix table 1-27). About 33% of mathematics teachers in 2007, compared with 37% in 2003, identified unpreparedness for learning as a serious problem at their schools. Similar reductions were observed among science teachers.

Although these improvements were small overall, most of the improvement in teachers' responses occurred at schools with high concentrations of low-income and minority students. For example, in 2003, 48% of mathematics teachers at high-poverty schools reported that student apathy was a serious problem, compared with 12% at low-poverty schools—a

Figure 1-11
Salaries of public middle and high school mathematics teachers and teacher satisfaction with salaries, by minority enrollment and school poverty level: Academic year 2007–08



NOTES: School poverty level is percentage of students in school qualifying for free/reduced-price lunch. Average salaries have been rounded to the nearest 100.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of 2007–08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-24.

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gap of 36 percentage points (figure 1-13). In 2007, that gap had closed by about 20 percentage points, with fewer teachers at high-poverty schools reporting this as a serious problem. A similar change occurred in mathematics teachers reporting students' lack of preparedness for learning as a serious problem: the gap between teachers at high- and low-poverty schools shrank from 52 percentage points in 2003 to about 36 in 2007.

Transition to Higher Education

Preparing students for postsecondary education is an important goal of high schools in the United States. This section presents indicators related to students' transitions from high school to college. It begins with data on high school completion rates in the United States, followed by international comparisons of high school graduation rates. It then examines students' expectations for enrolling in college, the proportion of students enrolling in college immediately after completing high school, and the relative international standing of postsecondary enrollment rates in the United States. Together, these data present an overview of the nation's effectiveness in preparing students for postsecondary education, the topic of the next chapter.

Completion of High School

On-Time Graduation Rates

The on-time graduation rate in the United States is the percentage of students who graduate with a regular high school diploma 4 years after entering ninth grade. In 2009, 76% of students completed high school on time (table 1-9), an improvement from 73% in 2006 (Chapman, Laird, and KewalRamani 2010; Stillwell and Hoffman 2008). Asian/Pacific Islander students graduated on time at a higher rate than white students did (92% versus 82%).

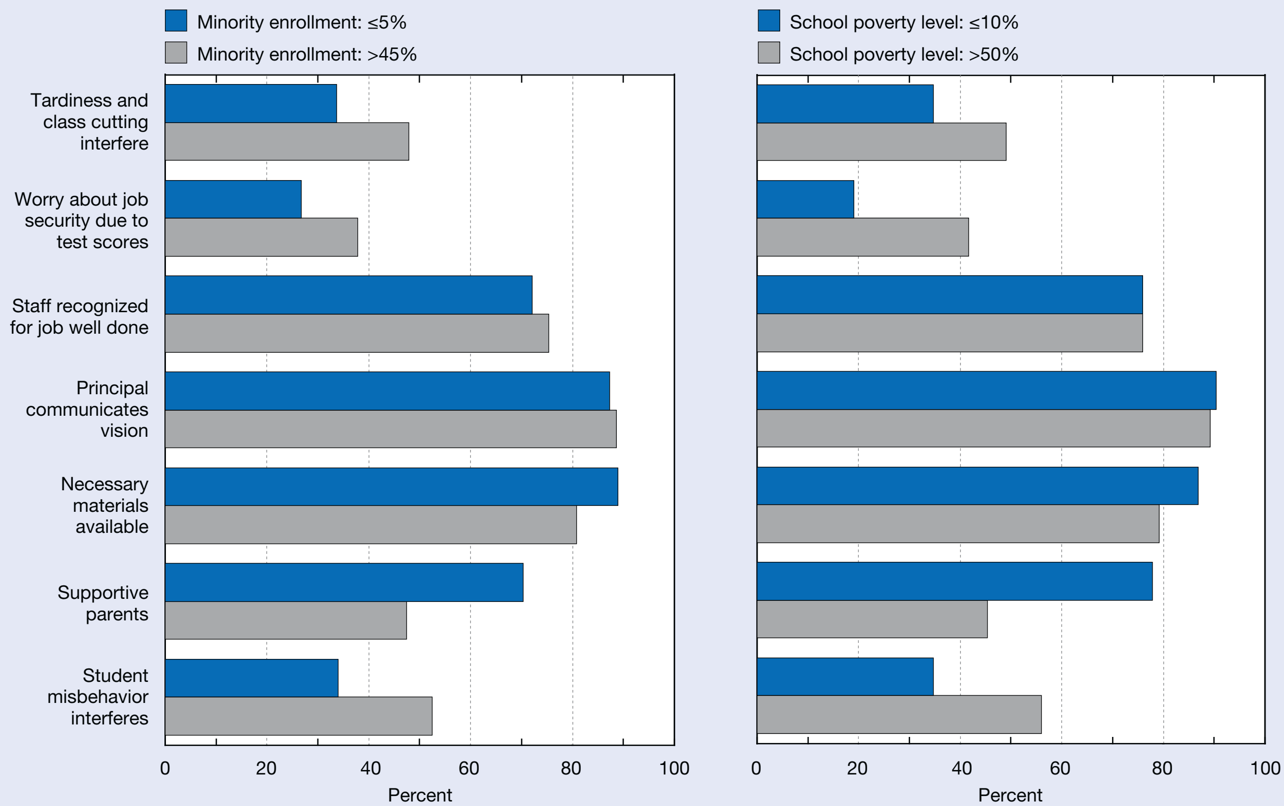
Students of other races and ethnicities graduated at lower rates. Rates of black, Hispanic, and American Indian/Alaska Native students were lowest, at 64%, 66%, and 65%, nearly 20–30 percentage points below the rate of white and Asian/Pacific Islander students. These rates have increased slightly since 2006, however, when they stood at 59%, 61%, and 62% respectively (Stillwell and Hoffman 2008). The gaps in on-time graduation rates between white and black students and between white and Hispanic students have declined slightly since 2006, by 3 percentage points.

Many students who did not complete high school within 4 years eventually went on to earn a high school diploma or equivalency credential. In 2008, an estimated 90% of 18- to 24-year-olds who were not enrolled in high school had received a high school diploma (84%) or earned an equivalency credential (6%), such as a General Educational Development (GED) certificate (Chapman, Laird, and KewalRamani 2010). Although most colleges and employers accept the GED as an alternative to a regular high school diploma, GED recipients do not fare as well as diploma holders across a variety of measures, including college completion rates and lifetime earnings (Chapman, Laird, and KewalRamani 2010).

Historically, not all states have used the same method for calculating graduation rates, leading to wide variation in the rates reported by each state. To facilitate state-by-state comparisons, the National Governors Association endorsed the NCES method as the standard method for calculating graduation rates in 2005, and all 50 governors agreed to work toward implementing that method (NGA 2005). This method calculates the high school graduation rate by dividing the number of graduates in a given year by the number of students who entered ninth grade 4 years earlier, adjusting the denominator for transfers into and out of the state over those 4 years.

Currently, 18 states use graduation rates calculated with this method to indicate whether they have met the graduation rate requirements for adequate yearly progress under NCLB (NGA 2010). Beginning with the 2011–12 school year, all states are required to use the NCES method. In addition, all states will be required to set and meet their own high

Figure 1-12
Perceptions of working conditions of public middle and high school mathematics teachers, by minority enrollment and school poverty level: Academic year 2007–08



NOTES: Teachers asked to indicate their agreement with various statements about their school conditions. Response categories included “strongly agree,” “somewhat agree,” “somewhat disagree,” and “strongly disagree.” Percentages based on teachers responding “strongly agree” or “somewhat agree” to various statements. School poverty level is percentage of students in school qualifying for free/reduced-price lunch.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of 2007–08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-25.

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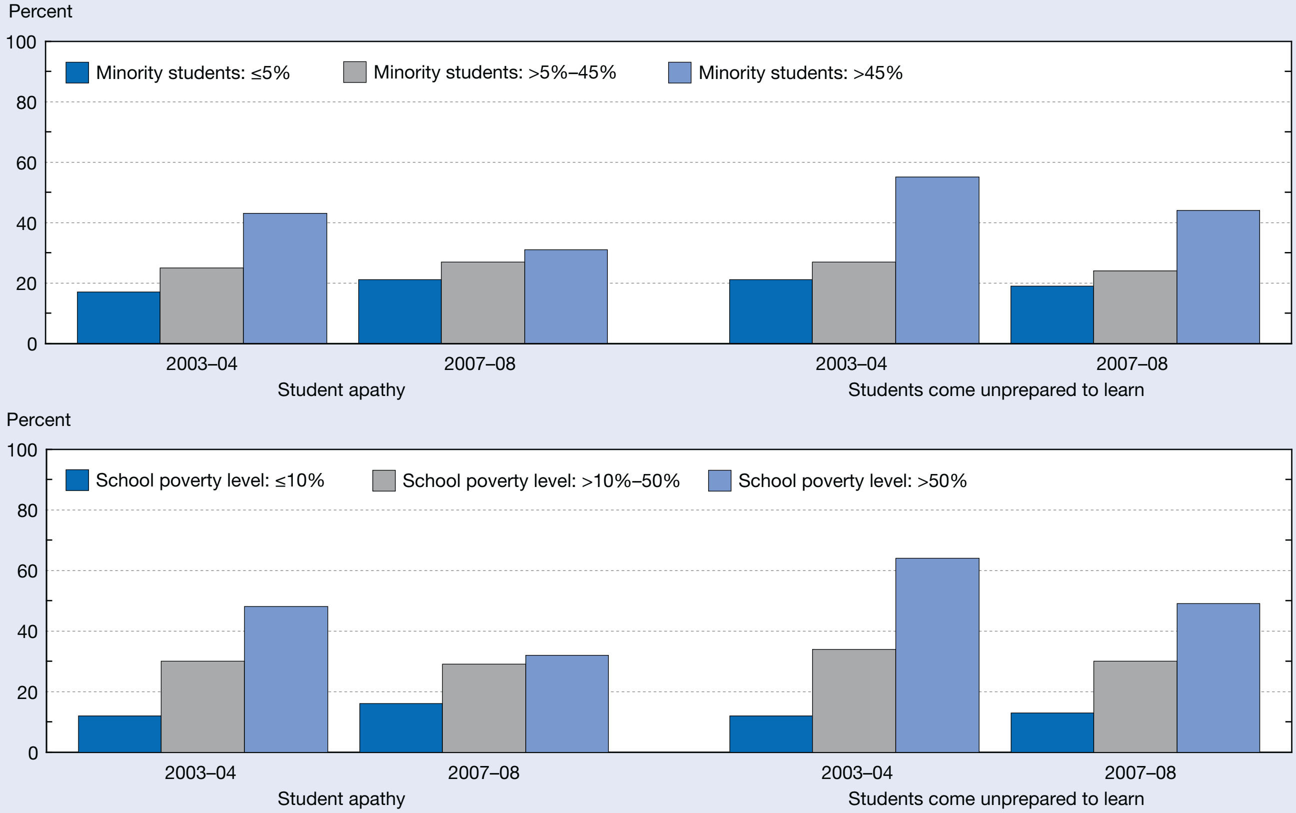
school graduation rate goals by 2014. As of summer 2010, 22 states had set the graduation rate goal at 90% or higher, and 27 states had set the goal between 80 and 89%, an improvement over previous years, when more than half the states set the goal at 75% or lower (NGA 2010; NSB 2010a). In 2008, the federal government issued revised graduation rate requirements, including the provision that, beginning in 2011–12, states and districts must meet not only overall graduation rate goals but also graduation rate goals for all student *subgroups* to achieve adequate yearly progress (U.S. Department of Education 2008).

Traditionally, rates of high school completion have been difficult to calculate accurately because of varying requirements for earning a regular diploma across states and districts and inadequate state data systems that track outcomes for individual students (Barton 2009). The increased demand for accurate data for federal accountability purposes, both for graduation rates and other school outcomes, has led states to develop data systems to track student progress more accurately. In 2005, the federal government created a grants program designed to support states in their efforts to create statewide longitudinal data systems. These systems will track individual students from pre-kindergarten through high school, college, and beyond (see sidebar “State Student Tracking Systems”).

High School Graduation Rates in the United States and Other OECD Nations

U.S. high school graduation rates calculated by OECD to articulate with reporting of other OECD members show that U.S. graduation rates are lagging behind those of other member countries. OECD calculates graduation rates by dividing the number of high school graduates in a country by the number of students of typical graduation age (OECD 2010a). Of the 25 OECD nations for which graduation rate data were available in 2008, the United States ranked 18th, with an average graduation rate of 77% compared with the OECD average of 80% (figure 1-14). The U.S. graduation rate remained at 77% from 2006 to 2008 according to OECD figures (OECD 2009, 2010b).

Figure 1-13
Serious student problems reported by public middle and high school mathematics teachers, by minority enrollment and school poverty level: Academic years 2003–04 and 2007–08



NOTES: Teachers asked to indicate the seriousness of various student problems in their schools. Response categories include “serious problem,” “moderate problem,” “minor problem,” and “not a problem.” Percentages based on teachers viewing various student problems as “serious.” School poverty level is percentage of students in school qualifying for free/reduced-price lunch.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2010) of 2003-04 and 2007-08 Schools and Staffing Survey, National Center for Education Statistics. See appendix table 1-27.

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Table 1-9
On-time graduation rates of U.S. public high school students, by race/ethnicity: 2006 and 2009
(Percent)

Race/ethnicity	2006	2009
All students	73.2	75.5
White	80.6	82.0
Black	59.1	63.5
Hispanic	61.4	65.9
Asian/Pacific Islander	89.9	91.8
American Indian/Alaska Native	61.8	64.8

NOTE: On-time high school graduation rate is percentage of entering ninth graders who graduated 4 years later.

SOURCES: Stillwell R, Hoffman L. Public School Graduates and Dropouts from the Common Core of Data: School Year 2005–06, National Center for Education Statistics (NCES), NCES 2008-353rev (2008); Stillwell R, Sable J, Plotts C, Public School Graduates and Dropouts from the Common Core of Data: School Year 2008–09, National Center for Education Statistics, NCES 2011-312 (2011).

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Enrollment in Postsecondary Education

A majority of high school seniors expect to continue their education after high school. Among the 2009 high school senior class, 86% of graduating students planned to attend a postsecondary institution in the first year after high school, with 62% planning to attend a 4-year institution, 19% planning to attend a 2-year college, and 5% planning to attend a vocational, technical, or business school (NCES 2010).

Not all students fulfilled these expectations for immediate college enrollment. Seventy percent of 2009 high school graduates had enrolled in a postsecondary institution by the October following high school completion (figure 1-15). Of these students, 28% enrolled in a 2-year college and 42% enrolled in a 4-year institution (appendix table 1-28).

From 1975 through 2009, the immediate college enrollment rate rose by 19 percentage points (from 51% to 70%). Female enrollment increased at a much higher rate (49% to 74%) than did male enrollment during the same period (53% to 66%). (For more detail on the gender gap in U.S. higher

State Student Tracking Systems

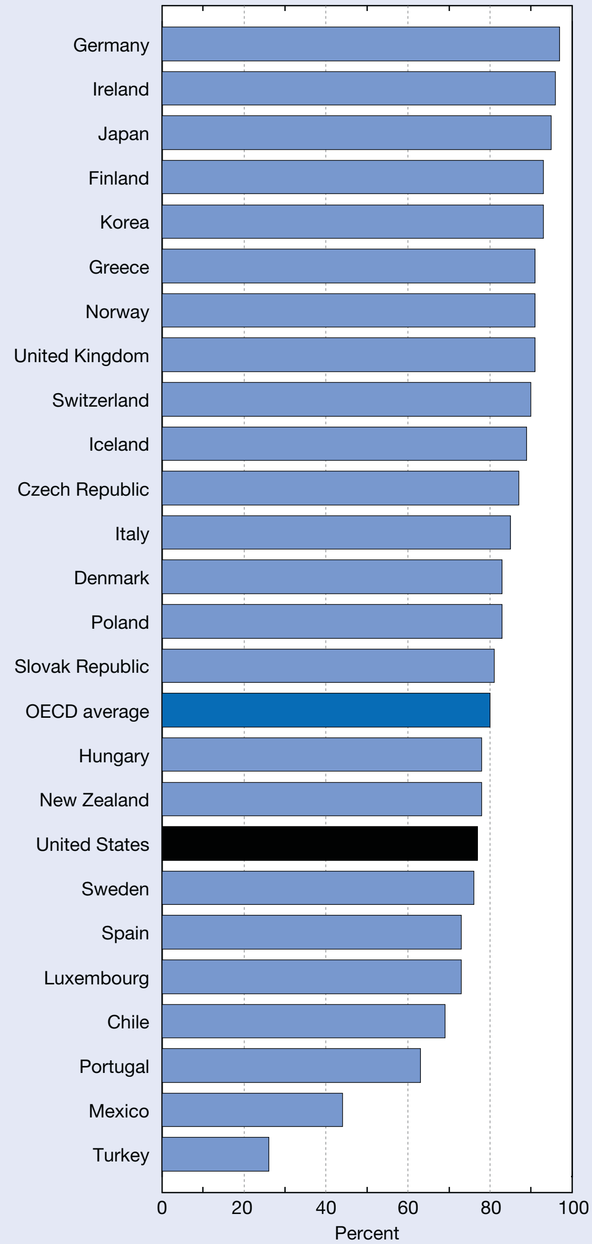
For the most part, existing state data systems are cross-sectional and do not track students over time. Statewide longitudinal data systems (SLDS) are designed to follow individual students from early childhood through high school and into postsecondary education and employment. The impetus for these new data systems comes from the need for more comprehensive and reliable data for accountability and evidence-based decisionmaking in education (DQC 2011a).

In 2005, the Institute of Education Sciences of the U.S. Department of Education introduced the SLDS Grant Program to encourage the development of these systems (IES 2011a). At the same time, a group of prominent education stakeholders launched the Data Quality Campaign to provide a national forum for discussions about SLDS implementation and to avoid duplication of effort and encourage collaboration across states (DQC 2011b). Although several states had been developing SLDS before 2005, most began designing their systems with the first round of federal funding in 2005, and many have made significant progress over the past 6 years (DQC 2011c). As of early 2011, for example, all states and the District of Columbia had collected student-level data on graduation and dropout rates (DQC 2011a).

Since 2005, 41 states and the District of Columbia have received at least one SLDS grant through one of four federal funding opportunities, including the American Recovery and Reinvestment Act (ARRA) (IES 2011b). To obtain ARRA funds, all governors and most legislatures agreed to implement SLDS that link preschool, K–12, postsecondary education, and workforce data and that conform to the requirements outlined in the America Competes Act by 2013 (U.S. Department of Education 2009). In addition, some states are linking their education data with data on corrections and social welfare assistance (Carson et al. 2010).

SLDS not only improve the quality of secondary and postsecondary education data, but also expose problems, such as the misalignment of state programs and inconsistencies in articulation of the data, that can then be addressed to improve education. SLDS are limited, however, by their inability to track students across state borders and into private colleges. A pilot project in Florida, Georgia, and Texas aims to develop a possible remedy for this problem by linking state data with college enrollment data from the National Student Clearinghouse (Bill & Melinda Gates Foundation 2010).

Figure 1-14
High school graduation rates, by OECD country: 2008



OECD = Organisation for Economic Co-operation and Development

NOTES: High school graduation rate is percentage of population at typical upper secondary graduation age (e.g., 18 years old in United States) completing upper secondary education programs. OECD average based on all OECD countries with available data. To generate estimates that are comparable across countries, rates are calculated by dividing the number of graduates in the country by the population of the typical graduation age.

SOURCE: OECD, *Education at a Glance: OECD Indicators 2010* (2010).

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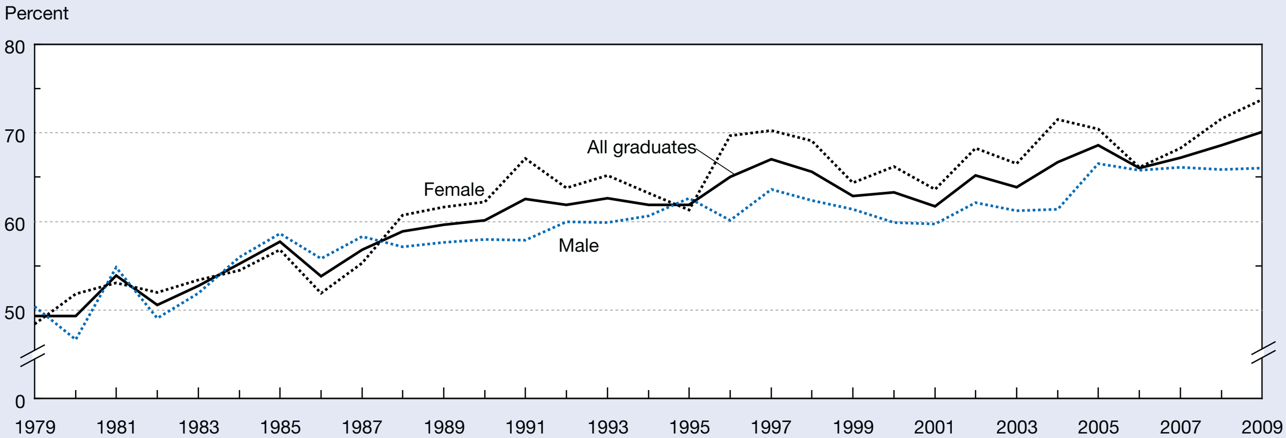
Figure 1-15
Immediate college enrollment rates among high school graduates, by sex: 1979–2009



NOTES: Includes students ages 16–24 completing high school in survey year. Immediate college enrollment rates defined as rates of high school graduates enrolled in college in October after completing high school.

SOURCE: Aud S, Hussar W, Kena G, Bianco K, Frohlich L, Kemp J, Tahan K. *The Condition of Education 2011,* National Center for Education Statistics (NCES), NCES 2011-033 (2011). See appendix table 1-28.

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education enrollment and degree attainment, see chapter 2 sidebar “Gender Gap in Undergraduate Education.”)

Immediate college enrollment in the United States is associated with parental education levels and family income. In 2009, 40% of students whose parents had less than a high school education enrolled in college immediately after high school completion, compared with 82% of students whose parents had a bachelor’s or advanced degree (appendix table 1-28). Students from high-income families enrolled in college at higher rates than did students from middle- or low-income families (84% versus 67% and 55%, respectively) in 2009.

The rate of immediate enrollment in college for white students was 71%, compared with 63% for black and 62% for Hispanic students. Immediate college enrollment rates for black and Hispanic students have increased over time, showing gains of about 6 percentage points for blacks and 7 percentage points for Hispanics since 2002. However, the white-black and white-Hispanic gaps persisted over time.

Postsecondary Enrollment in an International Context

According to OECD data, the percentage of U.S. young adults enrolling in college for the first time was 64% in 2008. The overall average was 56% for the 25 countries participating in the study. The United States ranked 11th out of 25 in 2008 (appendix table 1-29). The data show that females enroll in college at higher rates than males in most OECD countries, including the United States. In the United States, females enrolled at a rate of 72% (compared with the OECD average of 63%), and males enrolled at a rate of 57% (compared with 50% internationally) (OECD 2010a).

Conclusion

Indicators in this chapter produce a mixed picture of the progress of elementary and secondary mathematics and science education in the United States. Although improvements are evident in many areas, overall they are slow and uneven. Gaps among students of different demographic backgrounds and among schools with different student populations have been a persistent challenge in K−12 education in the United States. These gaps are reflected in many indicators in this chapter, including teacher qualifications, school environment, and, ultimately, learning outcomes.

NAEP mathematics and science assessment results show that, although average mathematics scores for 8th graders have improved steadily since 1990 and average mathematics scores for 12th graders have increased between 2005 and 2009, improvement among 4th graders leveled off in 2009. Achievement gaps are found among many student subgroups. Whereas boys performed slightly better than girls in both subjects, relatively larger gaps existed among students of different racial/ethnic backgrounds or with different family incomes. Over time, some gaps narrowed at grade 4: gaps in mathematics achievement between white and black students, between high- and low-performing students, and between private and public school students were smaller in 2009 than in 1990.

Overall, large majorities of 4th, 8th, and 12th graders did not demonstrate proficiency in the knowledge and skills taught at their grade level. While a majority of ninth graders reached proficiency in low-level algebra skills, few mastered higher level skills. Results of international mathematics and science literacy tests show that U.S. 15-year-olds continue to lag behind their peers in many other countries, even though their scores have improved somewhat in recent years.

Efforts to improve student achievement include raising high school graduation requirements, strengthening the rigor of curriculum standards, increasing advanced coursetaking, promoting early participation in gatekeeper courses such as algebra I, and improving teaching quality. From 1987 to 2008, the number of states requiring at least 3 years of mathematics and science courses for high school graduation increased from just a few states to more than 30. By the end of 2010, 44 states had adopted a common set of rigorous academic standards designed to ensure that students graduate from high school prepared for college and careers. Trend data from 1990 to 2009 show an upward trend of students earning more mathematics and science credits and participating in advanced mathematics and science courses. Nevertheless, completion rates in some advanced courses remained relatively low, and wide gaps in advanced mathematics and science coursetaking persisted among racial/ethnic subgroups.

Indicators related to teaching quality show that virtually all mathematics and science teachers in public middle and high schools have such basic credentials as a bachelor's degree and teaching certificate, and proportionally more mathematics and science teachers had advanced degrees in 2007 than in 2003. Likewise, more science teachers held full certification in 2007 than in 2003. Large majorities of mathematics and science teachers in high school also had a degree and/or certificate in their teaching field. Although in-field mathematics and science teachers are not as prevalent in middle schools as in high schools, the percentage of such teachers in middle schools has increased in recent years. Mathematics and science teachers with these qualifications are not evenly distributed across schools, however: schools with lower concentrations of minority and low-income students tend to have higher proportions of teachers with advanced degrees, full certification, in-field preparation, and more experience.

An increasing proportion of new mathematics and science teachers entered the profession through alternative programs. These teachers often begin teaching before completing their training, engaging in practice teaching, or earning full state certification, and they are more often found in schools with high concentrations of minority and poor students. Nevertheless, a majority of new mathematics and science teachers in public middle and high schools participate in practice teaching before entering the teaching force, and many of them also participate in induction programs during their first year in the classroom. In addition, a majority of mathematics and science teachers participate in professional development activities during the school year, although the duration of many such activities is relatively short.

Annual attrition rates for public school mathematics and science teachers fluctuated in the range of 5–9% between 1988 and 2008. Although teachers' salaries have not kept pace with those in occupations requiring comparable education, most teachers had favorable perceptions of their working conditions. Teachers in high-minority and high-poverty schools were less likely than others to have such positive perceptions, but some gaps have narrowed in recent years.

Most high school students graduate with a regular diploma 4 years after entering ninth grade. On-time graduation rates have improved, though slowly. Significant racial/ethnic gaps exist, with white and Asian/Pacific Islander students having graduation rates higher than those of students of other races and ethnicities. The U.S. ranked 18th in graduation rates among 25 OECD countries with available data in 2008.

A majority of high school seniors expect to continue their education after high school, and many enroll in college directly after high school graduation. Immediate college enrollment rates have increased for all students as well as for many demographic subgroups. Gaps persisted, however. Black students, Hispanic students, low-income students, and students whose parents have less education enroll in college at rates lower than their counterparts.

Notes

1. The terms *achievement* and *performance* are used interchangeably in this section when discussing scores on mathematics and science assessments.

2. Differences between two estimates were tested using Student's *t*-test statistic to minimize the chances of concluding that a difference exists based on the sample when no true difference exists in the population from which the sample was drawn. These tests were done with a significance level of 0.05, which means that a reported difference would occur by chance no more than once in 20 samples when there was no actual difference between the population means.

3. Race to the Top is a $4.35 billion competitive grant program funded by the U.S. Department of Education as part of the American Rec overy and Reinvestment Act of 2009. This program is designed to encourage and reward states creating the conditions for education innovation and reform, achieving significant improvement in student outcomes, and implementing reform plans in four core areas: 1) adopting standards and assessments that prepare students to succeed in college and the workplace; 2) building data systems that measure student growth and success and inform teachers and principals how to improve instruction; 3) recruiting, developing, rewarding, and retaining effective teachers and principals; and 4) turning around the lowest performing schools. In March 2010, Delaware and Tennessee won grants in the first phase of the competition, receiving approximately $100 million and $500 million, respectively, to implement their comprehensive school reform plans. In August 2010, nine states (Florida, Georgia, Hawaii, Maryland, Massachusetts, New York, North Carolina, Ohio, and Rhode Island) and the District of Columbia won grants in the second phase of the competition. Grant levels depend on a state's student population: large states like New York and Florida receive up to $700 million and smaller states like Hawaii and Rhode Island receive up to $75 million. See the Race to the Top

Fund website for more information: http://www2.ed.gov/programs/racetothetop/index.html.

4. The U.S. Department of Education awarded School Improvement Grants to states under the Elementary and Secondary Education Act of 1965 (reauthorized in 2002 as the No Child Left Behind Act) to support focused school improvement efforts. In 2009, the department dramatically increased the funds that would be provided to states (from $491,265 in 2008 to $3.546 billion in 2009) and charged states with using the funds for leveraging changes needed to turn around persistently low-achieving schools.

5. These two NAEP assessment programs differ in many aspects, including samples of students and assessment times, instruments, and contents. See http://nces.ed.gov/nationsreportcard/about/ltt_main_diff.asp.

6. The 2010 volume reviewed long-term trends in mathematics from 1973 to 2008, and the 2004 volume examined trends in science from 1969 to 1999. The long-term trend assessment in mathematics will be administered again in 2012; the long-term trend assessment in science has not been conducted since 1999.

7. Students in the below-basic category have scores lower than the minimum score for the basic level. Students in the basic category have scores at or above the minimum score for the basic level, but lower than the minimum for the proficient level. Students in the proficient category have scores at or above the minimum score for the proficient level, but lower than the minimum score for the advanced level. Students in the advanced category have scores at or above the minimum score for the advanced level.

8. See NAEP's mathematics and science achievement levels defined by grade at http://nces.ed.gov/nationsreportcard/mathematics/achieveall.asp and http://nces.ed.gov/nationsreportcard/science/achieveall.asp.

9. Percentiles are scores below which a specified percentage of the population falls. For example, among fourth graders in 2009, the 10th percentile score for mathematics was 202. This means that 10% of fourth graders had mathematics scores at or below 202 and 90% scored above 202. The scores at various percentiles indicate students' performance levels.

10. In 2005, NAGB adopted a new mathematics framework for the grade 12 assessment to reflect contemporary standards of high school curriculum and coursework. Based on this new framework, the 2005 assessment changed its content areas (e.g., increasing coverage on algebra, data analysis, and probability) and adopted a new reporting scale (i.e., 0–300 as opposed to 0–500 in earlier years). These changes made the 2005 assessment results not comparable to those in earlier years. Some changes were also made to the 2009 framework; the purpose was to enable NAEP to better measure how well prepared 12th grade students are for postsecondary education and training (e.g., adding content that is beyond what is typically taught in a standard 3-year course of study in high school mathematics). However, special analyses of 2005 and 2009 data determined that the 2009 grade 12 mathematics results could still be compared with results from the 2005 assessment despite the changes to the 2009 framework. More information about the mathematics frameworks for the 2005 and 2009 grade 12 assessments and how they differ from the previous framework is available at http://nces.ed.gov/nationsreportcard/mathematics/frameworkcomparison.asp.

11. Results for private school students in 2009 could not be reported separately due to the low participation rate for private schools.

12. Special NSF tabulations.

13. Students' eligibility for free/reduced-price lunch is often used as a proxy measure of family poverty. Students who are eligible for free/reduced-price lunch are considered to come from low-income families, and those who are not eligible for free/reduced-price lunch are considered to come from relatively high-income families.

14. Data on parental education for grade 4 were unreliable and therefore excluded from the analysis.

15. Cross-grade comparisons are acceptable for mathematics scores of fourth and eighth graders because these scores were put on a common scale. However, mathematics scores for 4th and 8th graders cannot be compared to those of 12th graders because they used different score scales (0 to 500 for grades 4 and 8 and 0 to 300 for grade 12). Cross-grade comparisons are also not appropriate for other subjects because the scales were derived independently at each grade level. See http://nces.ed.gov/nationsreportcard/mathematics/interpret-results.asp.

16. Gender gaps are not consistent across racial/ethnic subgroups. For example, the results from the 2009 NAEP mathematics assessment show that, whereas white and Hispanic boys had higher scores than their girl counterparts at grade 4, the pattern was opposite among blacks—girls outperformed boys. Similar differences were also found among students in grade 8 (special NSF tabulations).

17. Differences in performance between public and private school students reflect in part different types of students enrolled in public and private schools. Proportionally, private schools enroll more white students and students from advantaged socioeconomic backgrounds than public schools (Snyder and Dillow 2011).

18. The reduction in the white-black gap at grade 4 is likely attributable to larger improvements made by black female students (Vanneman et al. 2009). From 1990 to 2007, the average mathematics score gains of black females at grade 4 were greater than those of their white peers, reducing the white-black gap. However, among male students at grade 4, no similar gap reductions were observed during this period.

19. Previous volumes of *Science and Engineering Indicators* (e.g., NSB 2010b) also used data from the Trends in International Mathematics and Science Study (TIMSS) to examine the relative standing of U.S. students in mathematics and science achievement. No new data from TIMSS, however, were available when this chapter was prepared. The latest administration of TIMSS was in spring 2011, and international comparisons based on TIMSS data will be

available in the 2014 volume of *Science and Engineering Indicators*.

20. Information on OECD and its assessment programs is available at http://www.pisa.oecd.org/pages/0,2987,en_32252351_32235731_1_1_1_1_1,00.html.

21. PISA differs from NAEP in several key aspects. NAEP assesses the knowledge and skills students need for an in-depth understanding of mathematics and science at various grade levels. PISA measures the "yield" of education systems, that is, the skills and competencies students have acquired and can apply in real-world contexts by age 15. NAEP emphasizes curriculum-based knowledge, whereas PISA focuses on literacy and applications, drawing on learning both in and outside of school. Although NAEP and PISA both are sample-based assessments, NAEP uses grade-based samples of students in grades 4, 8, and 12, and PISA uses an age-based sample of 15-year-old students nearing completion of compulsory schooling in many countries. Both assessments are developed from a framework specifying the content and skills to be measured, but the PISA framework is organized around overarching ideas (e.g., space and shape) with emphasis on the contexts in which concepts are applied (e.g., in school, in society), as opposed to curriculum-based topics, such as geometry and algebra.

22. In this section, "coursetaking" refers only to completed courses for which students earned at least one credit. The High School Transcript Study contains no data on students who did not graduate or who may have enrolled in a course but did not complete it.

23. Not all high schools have the same standards for course titles and content. To allow comparisons, HSTS standardizes the transcript information. To control for variation in course titles, a coding system called the Classification of Secondary School Courses is used for classifying courses on the basis of information in school catalogs and other information sources. (For more information, see http://nces.ed.gov/surveys/hst/courses.asp.)

24. Advanced mathematics course categories used in this edition are based on the categories reported by HSTS for 2009. HSTS has changed these categories since 2005, so the percentages shown in figures 1-5 and 1-6 are not comparable to those reported in previous editions.

25. HSTS converts high schools' transcript credits to standardized Carnegie units of credit (or Carnegie credits), in which a single unit is equal to 120 hours of classroom time over the course of a year. A credit is equivalent to a 1-year course in a subject.

26. Precalculus/analysis includes courses referred to as mathematics analysis courses, but they include the same content as precalculus courses.

27. Advanced science course categories used in this edition are based on the categories reported by HSTS for 2009. HSTS has changed these categories since 2005, so the percentages for each subject area shown in figure 1-7 are not comparable to those reported in previous editions.

28. AP/IB science courses were not coded separately in 1990 and therefore are not reported for that year.

29. Of 500 possible points awarded to grant applications, 138 points, or 28% of the total, were given to plans for "Great Teachers and Leaders." Specifically, plans were solicited for providing high-quality pathways for aspiring teachers and principals (21 points), improving teacher and principal effectiveness based on performance (58 points), ensuring equitable distribution of effective teachers and principals (25 points), improving the effectiveness of teacher and principal preparation programs (14 points), and providing effective support to teachers and principals (20 points). Detailed information is available at http://www2.ed.gov/programs/racetothetop/executive-summary.pdf.

30. Middle and high school teachers, included in these indicators, are identified using a SASS variable that indicates the level of the school at which teachers are employed. Middle schools are defined as those with no grade lower than 5 and no grade higher than 8; high schools are defined as those with no grade lower than 7 and at least one grade higher than 8. Elementary school teachers, not included in these indicators, typically teach multiple subjects, and most of them hold a certification in general education.

31. Based on the percentage of students in school qualifying for free/reduced-price lunch.

32. To simplify the discussion, schools in which 10% or fewer of the students are eligible for the federal free and reduced-price lunch program are called low-poverty schools, and schools in which more than 50% of the students are eligible are called high-poverty schools. Similarly, low-minority schools are those in which 5% or fewer of the students are members of a minority, and high-minority schools are those in which more than 45% of the students are members of a minority.

33. Probationary certification generally is awarded to those who have completed all requirements except for a probationary teaching period. Provisional or temporary certification is awarded to those who still have requirements to meet. States also issue emergency certification to those with insufficient teacher preparation who must complete a regular certification program to continue teaching (Henke et al. 1997). Teachers' type of certification differs from their pathway into the profession: teachers from both traditional and alternative programs may have any type of state certification in order to teach. Alternative-pathway teachers, however, are more likely to begin teaching with a provisional or temporary certification.

34. As of 2009, 48 states required teachers to pass a test covering topics such as basic academic skills and pedagogical knowledge to obtain certification (Editorial Projects in Education Research Center 2010).

35. In 2010, the National Academy of Sciences counted 130 alternative programs, differing in goals, requirements, structure, and candidate pools (NRC 2010). Some programs, such as Teach for America, receive direct federal support, and others are themselves federal programs, such as the U.S. Department of Defense's "Troops to Teachers" program, which facilitates the entry of military personnel into teaching careers. Race to the Top, a federal competitive grant

program encouraging certain education reforms, awarded points to applicant states for providing high-quality alternative pathways for aspiring teachers.

36. Large variation has been observed between programs within each pathway (Boyd et al. 2008).

37. More information about these programs is available at http://www.teachforamerica.org and https://tntp.org/about-tntp. Information about the Troops to Teachers program is available at http://www2.ed.gov/programs/troops/index.html.

38. More information about National Board Certification is available at http://www.nbpts.org.

39. Information on the number of teachers is available at http://www.nbpts.org/about_us/national_board_certifica1/national_board_certifica; information on their diversity initiatives and teacher placement is at http://www.nbpts.org/resources/diversity_initiatives.

40. Research suggests that characteristics of the practice teaching placement and program affect subsequent teacher effectiveness. In New York City, teachers who were placed in easy-to-staff schools during their practice teaching were more likely to remain teaching in the district and see gains in student achievement, regardless of the characteristics of the school at which they were ultimately employed (Ronfeldt 2010); teachers whose preparation programs provided oversight of their practice teaching and required a capstone project saw larger student achievement gains during their first year (Boyd et al. 2008).

41. For a slightly different measurement of in-field teaching, see *Education and Certification Qualifications of Departmentalized Public High School-Level Teachers of Core Subjects: Evidence From the 2007–08 Schools and Staffing Survey* (NCES 2011-317), http://nces.ed.gov/pubs2011/2011317.pdf.

42. A recent experimental study of professional development for middle school mathematics teachers found that a 2-year training program for 7th-grade mathematics teachers had no effect on either teacher knowledge or student performance (Garet et al. 2011). A report from the study's first year found that the training did significantly increase the frequency of one "good practice" for teaching mathematics: engaging in activities that elicit student thinking (Garet et al. 2010).

43. The maximum duration SASS provides as an option in its teacher questionnaire is "33 hours or more," which is reported in this chapter. Research suggests that teachers who receive content-focused professional development already have relatively strong content knowledge (Desimone, Smith, and Ueno 2006).

44. The statements about working conditions included in this section represent a selection of those measured in SASS. For a complete list of questions and results for public elementary and secondary teachers, see http://nces.ed.gov/programs/digest/d10/tables/dt10_076.asp.

Glossary

Student Learning in Mathematics and Science

Eligibility for National School Lunch Program: Student eligibility for this program, which provides free or reduced-price lunches, is a commonly used indicator for family poverty. Eligibility information is part of the administrative data kept by schools and is based on parent reported family income and family size.

Repeating cross-sectional studies: This type of research focuses on how a specific group of students performs in a particular year, and then looks at the performance of a similar group of students at a later point in time. An example would be comparing fourth graders in 1990 to fourth graders in 2009.

Scale score: Scale scores place students on a continuous achievement scale based on their overall performance on the assessment. Each assessment program develops its own scales.

Student Coursetaking in High School Mathematics and Science

Advanced Placement: Courses that teach college-level material and skills to high school students who can earn college credits by demonstrating advanced proficiency on a final course exam. The curricula and exams for AP courses, available for a wide range of academic subjects, are developed by the College Board.

International Baccalaureate: An internationally recognized pre-university academic subject course designed for high school students.

Teachers of Mathematics and Science

High schools: Schools that have at least one grade higher than 8 and no grade in K–6.

Main teaching assignment field: The field in which teachers teach the most classes in school.

Major: A field of study in which an individual has taken substantial academic coursework at the postsecondary level, implying that the individual has substantial knowledge of the academic discipline or subject area.

Middle schools: Schools that have any of grades 5–8 and no grade lower than 5 and no grade higher than 8.

Practice teaching: Programs designed to offer prospective teachers hands-on classroom practice. Practice teaching is often a requirement for completing an educational degree or state certification, or both.

Professional development: In-service training activities designed to help teachers improve their subject-matter knowledge, acquire new teaching skills, and stay informed about changing policies and practices.

Secondary schools: Schools that have any of grades 7–12 and no grade in K–6.

Teaching certification: A license or certificate awarded to teachers by the state to teach in a public school. Certification typically includes the following five types:

(1) regular or standard state certification or advanced professional certificate; (2) probationary certificate issued to persons who satisfy all requirements except the completion of a probationary period; (3) provisional certificate issued to persons who are still participating in what the state calls an "alternative certification program"; (4) temporary certificate issued to persons who need some additional college coursework, student teaching, and/or passage of a test before regular certification can be obtained; and (5) emergency certificate issued to persons with insufficient teacher preparation who must complete a regular certification program to continue teaching.

Teacher induction: Programs designed at the school, local, or state level for beginning teachers in their first few years of teaching. The purpose of the programs is to help new teachers improve professional practice, deepen their understanding of teaching, and prevent early attrition. One key component of such programs is that new teachers are paired with mentors or other experienced teachers to receive advice, instruction, and support.

Transition to Higher Education

Postsecondary education: The provision of a formal instructional program with a curriculum designed primarily for students who have completed the requirements for a high school diploma or its equivalent. These programs include those with an academic, vocational, or continuing professional education purpose and exclude vocational and adult basic education programs.

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