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Chapter 1
Elementary and Secondary Mathematics and Science Education

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Highlights

Student Learning in Mathematics and Science

U.S. fourth and eighth graders have made substantial gains in mathematics since 1990. Although eighth grade scores show a continuous upward trend, fourth grade scores leveled off during recent years. In science, 2011 eighth graders performed slightly better than their counterparts tested in 2009.

- The average mathematics score at grade 4 rose by 27 points from 1990 to 2007 and then remained essentially flat from 2007 to 2011.
- The average mathematics score at grade 8 increased steadily from 1990 to 2011 with a total gain of 21 points over the period.
- The average science score at grade 8 improved slightly, increasing from 150 in 2009 to 152 in 2011. (Earlier science assessment scores were not comparable with recent ones because of framework changes).

Despite improvement, relatively few students reached their grade-specific proficiency levels in mathematics and science on the 2011 National Assessment of Educational Progress.

- In mathematics, the percentage of students reaching the proficient level remained well below half in 2011: 40% of fourth graders and 35% of eighth graders performed at or above this level.
- In science, 32% of eighth graders performed at or above the proficient level for their grade in 2011.

Performance disparities in mathematics and science were evident among different demographic groups at grades K, 4, and 8. Some score gaps narrowed over time, however.

- At grades K, 4, and 8, students from low-income families or homes where the primary language used was not English had lower mathematics and science scores than their peers from more advantaged backgrounds.
- Black, Hispanic, and American Indian or Alaska Native students performed substantially lower than their white and Asian or Pacific Islander counterparts.
- Sex differences in achievement were generally small and favored boys in most cases. Among black students, however, girls performed better.
- Some gaps in mathematics narrowed over time at grade 4. Between 1990 and 2011, the score gaps decreased between white and black students (from 32 to 25 points) and between low- and high-performing students (i.e., at the 10th and 90th percentiles) (from 82 to 73 points).
- Some gaps in science also narrowed somewhat during the relatively short period of time from 2009 to 2011. The white-black gap decreased from 36 to 34 points. The white-Hispanic gap fell from 30 to 26 points. The gap between low- and high-performing students dropped from 89 to 87 points.

Although U.S. fourth and eighth graders outperformed students in many other countries/jurisdictions on the 2011 Trends in International Mathematics and Science Study (TIMSS) tests, they were not among the very top-achieving groups in the world.

- The U.S. average score on the 2011 TIMSS mathematics assessment was substantially lower than those of seven countries/jurisdictions at grade 4 and those of six countries/jurisdictions at grade 8. The top performers—Singapore, Republic of Korea, and two cities (Hong Kong and Taipei)—each scored at least 50 points higher than the United States at grade 4 (591−606 versus 541) and at least 77 points higher than the United States at grade 8 (586−613 versus 509).
- Between 1995 and 2011, U.S. fourth and eighth graders improved both their scores and international ranking in mathematics. In science, U.S. eighth graders' performance improved, but their relative international ranking was unchanged. U.S. fourth graders' science performance did not change, and their relative international position slipped.

Student Coursetaking in Mathematics and Science

Algebra 1 and biology 1 were the most common subjects taken by ninth graders in 2009.

- In mathematics, 52% of ninth graders reported enrollment in algebra 1. In addition, 29% reported enrollment in courses above algebra 1, such as geometry.
- In science, 38% of ninth graders reported enrollment in biology 1, with 32% in earth/environmental/physical science courses and 7% in courses above biology 1.
- Nearly twice as many ninth graders reported no science enrollment (18%) as reported no mathematics enrollment (10%).

Ninth grade coursetaking in mathematics and science in 2009 varied by parental education and socioeconomic status (SES).

- Students who had at least one parent with a master's degree or higher were more than twice as likely to report enrollment in a mathematics course above algebra 1 (51%) as were their peers whose parents had less than a 4-year college degree (22%).

- More than one-fourth of students in the lowest SES category reported no science enrollment (27%), compared with 11% of students in the highest SES category.
- About 17% of students in the lowest SES category reported no mathematics enrollment, compared with 6% of those in the highest SES category.

The number of students taking at least one Advanced Placement (AP) exam in mathematics or science has doubled in the past decade from 250,000 students in the class of 2002 to 500,000 students in the class of 2012.

- Calculus AB and biology were the most popular AP exams in mathematics and science, with 212,000 students in the graduating class of 2012 taking calculus AB and 153,000 students taking biology.
- Although more students in the class of 2012 were taking AP exams, the AP program in mathematics and science involved a relatively small proportion of all high school students. Just 17% of all students took an AP mathematics or science exam, with 9% passing.

Although increasing numbers of students are taking AP exams, passing rates (a score of 3 or higher out of 5) have declined or remained steady in most mathematics and science subjects.

- The overall passing rate for any AP mathematics or science exam dropped from 62% in 2002 to 54% in 2012.
- The two most popular exams, calculus AB and biology, showed the largest decreases, with average passing rates dropping by 9 percentage points for calculus AB and 13 percentage points for biology since 2002.

The proportion of male and female students in the class of 2012 taking mathematics and science exams varied by subject. Black and Hispanic students were underrepresented among AP exam takers.

- Male students were more likely than female students to take advanced AP courses, including calculus BC (59% versus 41%), physics B (65% versus 35%), and both physics C courses (about 75% versus 25%).
- Female students were more likely than male students to take AP exams in biology (59% versus 41%) and environmental science (55% versus 45%). Male students were four times more likely than female students to take the computer science A exam (81% versus 19%).
- Black students made up about 15% of the 2012 graduating class, but they represented less than 8% of students taking any AP mathematics or science exam.
- Hispanic students made up about 18% of the class of 2012, but their representation among AP exam takers ranged from a high of 15% for environmental science to a low of 8% for calculus BC and 7% for physics C: electricity/magnetism.

Teachers of Mathematics and Science

Novice science teachers—those with 2 or fewer years of experience—are more prevalent at schools with the highest proportions of low-income and non-Asian minority students.

- In 2012, 23% of science classes at schools with the highest concentrations of students eligible for free/reduced-price lunch (i.e., 75%–100% of students) were taught by novice teachers, compared with 10% of science classes at schools with the lowest concentrations of free/reduced-price lunch-eligible students (i.e., 0%–25% of students).
- Similarly, 21% of science classes at schools with the highest concentrations of non-Asian minority students were taught by novice teachers, compared with 14% of classes at schools with the lowest concentrations of non-Asian minority students.
- Students in high-poverty schools were more likely to have novice teachers in science than in mathematics: 23% of science classes compared with 14% of mathematics classes were taught by teachers with 2 or fewer years of experience.

A majority of high school mathematics and science teachers hold degrees in their teaching field or in science or mathematics education.

- In 2012, 73% of high school mathematics teachers had an undergraduate or graduate degree in mathematics or mathematics education, and 82% of high school science teachers had an undergraduate or graduate degree in science (any subject), engineering, or science education.
- A small percentage (4%–5%) of elementary school teachers of mathematics or science held a degree in mathematics or science.
- Mathematics and science classes with the highest concentrations of non-Asian minority students or the lowest-achieving students were less likely to be taught by teachers with a degree in their teaching field.

Elementary teachers are much more confident in their ability to teach mathematics than in their ability to teach science.

- In 2012, 77% of elementary teachers reported feeling very well prepared to teach mathematics, compared with 39% reporting they felt very well prepared to teach science.
- About half of mathematics and science teachers at most levels felt very well prepared to encourage the participation of female students in mathematics and science. Elementary teachers of science were an exception—only 30% felt well prepared to encourage female students to participate in science.

A majority of middle and high school mathematics and science teachers participated in at least one professional development activity that focused on mathematics or science in the 3 years prior to 2012.

- The participation rate for middle and high school mathematics and science teachers ranged from 82% to 89%.
- Among elementary school teachers, 87% participated in at least one math professional development activity, and 59% participated in at least one science professional development activity in the 3 years prior to 2012.
- In 2012, 32% of high school mathematics teachers and 36% of high school science teachers reported that they had spent more than 35 hours in subject-specific professional development activities during the prior 3 years. Far fewer elementary school teachers of mathematics (11%) or science (4%) reported participating in subject-specific professional development activities for more than 35 hours.

Overall, schools are more supportive of mathematics instruction than science instruction.

- In 2012, 82% of mathematics program representatives reported that the importance their school placed on mathematics teaching promoted effective instruction in mathematics, whereas 60% of science program representatives reported that this was the case.
- About 70% of mathematics program representatives, compared with about 50% of science program representatives, reported that school management of instructional resources promoted effective instruction in mathematics or science.
- Various problems were viewed as serious barriers to effective instruction. For mathematics instruction at the high school level, the most frequently cited problem was low student interest in mathematics. At the elementary level, low student reading abilities was the most frequently cited barrier to effective mathematics instruction.
- For science instruction, frequently cited problems included inadequate funds for purchasing equipment and lack of science facilities. At the elementary level, more than one-quarter of program representatives reported insufficient time to teach science as a serious problem for science instruction.

Secondary mathematics and science teachers had higher 3-year attrition rates than did their colleagues who taught at the elementary level or taught other fields at the secondary level.

- Among teachers who began teaching in 2007–08, one-quarter of secondary mathematics and science teachers had left teaching by 2009–10, compared with 11% of elementary teachers and 10% of secondary teachers of other fields.

Instructional Technology and Digital Learning

Access to the Internet in U.S. schools is nearly universal.

- In 2008, 98% of U.S. public school classrooms had Internet access, and the ratio of students to instructional computers was 3:1, compared with a ratio of 7:1 in 2000.

An increasing number of students have access to and are enrolling in distance education, particularly online learning.

- Online learning programs range from programs that are fully online with all instruction occurring via the Internet to hybrid or “blended learning” programs that combine face-to-face teacher instruction with online components.
- More than 1 million elementary and secondary students were enrolled in online or blended learning courses in 2007–08, a 47% increase from 2005–06.
- A recent nationally representative survey of public school districts found that providing courses not otherwise available at their schools and providing students with opportunities to recover course credits from classes missed or failed were the top reasons for offering online learning options.

Rigorous research examining the impact of instructional technology and online learning on student achievement remains limited.

- Three recent rigorous meta-analyses compared the mathematics achievement of students taught in classes using technology-assisted mathematics programs with that of students in control classes using standard methods. All three studies found small positive effects when technology was incorporated into classroom mathematics instruction.

Transition to Higher Education

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

- In 2010, 78% of public school students completed high school on time, up from 73% in 2006. All racial and ethnic groups made progress during this period, with improvement ranging from 3 percentage points for white students to 10 percentage points for Hispanic students.
- In 2010, Asian or Pacific Islander and white students graduated on time at a higher rate (94% and 83%, respectively) than did black, Hispanic, and American Indian or Alaska Native students (66%, 71%, and 69%, respectively).

The U.S. high school graduation rate lags behind those of many developed nations.

- The United States ranked 22nd out of 26 Organisation for Economic Co-operation and Development (OECD) countries for which graduation rate data were available in 2010, with an average graduation rate of 77% among the population of 18-year-olds, compared with the OECD average of 84%.
- The relative standing of U.S. high school graduation rates did not improve between 2006 and 2010, ranking 16th in both 2006 and 2008 and 17th in 2010 among the 21 OECD countries with available data.

The majority of U.S. high school graduates enroll in a postsecondary institution immediately after high school completion, but a sizeable percentage of entering students need remedial courses to prepare themselves for college-level work.

- Close to 70% of 2011 high school graduates had enrolled in a postsecondary institution by the October following high school completion, an increase of 17 percentage points since 1975.
- Relatively more female graduates than male graduates enrolled immediately in postsecondary education in 2011 (72% versus 65%).
- Students from high-income families enrolled at a higher rate (82%) than did students from middle-income (66%) or low-income families (53%).
- Internationally, the percentage of U.S. young adults enrolling in university-level education for the first time was 74% in 2010, above the OECD average of 62%. Among 30 OECD countries for which data were available, the United States ranked 9th.
- Half of beginning postsecondary students took some type of remedial course after entering college in 2003–04. The math remediation rate was 57% for those entering 2-year institutions and 29% for those entering 4-year institutions.

Introduction

Chapter Overview

U.S. education reform at the elementary and secondary levels continues to focus on improving students' learning. Reform goals include increasing student achievement, reducing performance gaps between students in different demographic groups, and raising the international ranking of U.S. students from the middle to the top on international tests (The White House n.d.).[1] Although policymakers have remained committed to these goals, strategies and efforts to promote them have shifted over time. Most recently, the federal government has given states seeking to meet these goals more flexibility by granting them waivers from the stringent standards required by the No Child Left Behind Act of 2001 (NCLB).[2] In exchange for the waivers, the states agreed to undertake essential reforms to raise standards, improve accountability, and enhance teacher effectiveness (U.S. Department of Education 2012a). In addition, the federal government created the Race to the Top (RTTT) grant program, inviting states to voluntarily participate in this program designed to promote state-led reform efforts (U.S. Department of Education 2009, 2011). Through grant competition, RTTT encourages states and local school districts to design and implement their own reform plans to address their unique educational challenges (see sidebar, "Race to the Top").

Concern about the ability of the United States to compete in the global economy has also lent urgency to calls for reform of science, technology, engineering, and mathematics (STEM) education (National Academy of Science 2005; NSB 2007). Federal and state policymakers and legislators have called for national efforts to develop a strong STEM pathway from high schools to colleges that eventually will expand the STEM-capable workforce in the United States (Kuenzi 2008; NGA 2011; President's Council of Advisors on Science and Technology 2012; The White House n.d). At the K−12 level, reform efforts to improve mathematics and science learning include increasing advanced coursetaking in these areas, promoting early participation in gatekeeper courses such as algebra 1, recruiting and training more mathematics and science teachers, designing new curricular standards for mathematics and science learning, and expanding secondary education programs that prepare students to enter STEM fields in college (Engberg and Wolniak 2013). Recently, the National Research Council (NRC) began working with the National Science Foundation (NSF) and the U.S. Department of Education to develop a new set of indicators that will track national progress in K−12 mathematics and science teaching and learning (see sidebar, "Monitoring Progress Toward Successful K−12 STEM Education").

Chapter Organization

To provide a national portrait of K−12 STEM education in the United States, this chapter compiles indicators of precollege mathematics and science learning based mainly on data from the National Center for Education Statistics (NCES) of the U.S. Department of Education. Table 1-1 contains an overview of the topics covered in this chapter and the indicators used to address them.

This chapter is organized into five sections. The first section begins with data from a new longitudinal study of U.S. kindergartners conducted in 2010−11. These data provide

Race to the Top

Race to the Top (RTTT) is a $4.35 billion competitive grant program funded by the U.S. Department of Education as part of the American Recovery and Reinvestment Act of 2009 (U.S. Department of Education 2009). The program provides monetary incentives for states and school districts to create conditions for education innovation and reform that would significantly improve student achievement (particularly in mathematics and science), narrow learning gaps, increase high school graduation rates, and increase the number of students admitted to college. To achieve these outcomes, RTTT focuses on reform strategies in four core areas:

- Adopting standards and designing assessments that prepare students to succeed in college and the workplace and to compete in a global economy;
- Building data systems that measure changes in student achievement and informing teachers and principals about how they can improve instruction;
- Recruiting, developing, rewarding, and retaining effective teachers and principals, especially where they are needed most; and
- Improving the performance of the lowest-achieving schools.

Since the launch of RTTT in 2009, a total of 18 states and the District of Columbia have won awards. In 2012, the Obama Administration launched an RTTT competition at the school district level. Known as Race to the Top–District, this program focuses on changes within schools and is targeted at supporting locally developed plans for improving classroom practices and resources. As of December 2012, the program made awards to 16 school districts across the nation. Additional information about RTTT is available at http://www2.ed.gov/programs/racetothetop/index.html.

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

Topic	Indicator
Student learning in mathematics and science	• Mathematics and science performance of first-time kindergarten students in the 2010–11 school year • Trends in fourth and eighth graders' mathematics performance from 1990 to 2011 • Eighth graders' science performance in 2009 and 2011 • International comparisons of fourth and eighth graders' mathematics and science achievement in 2011
Student coursetaking in mathematics and science	• Highest level of mathematics and science coursetaking by high school freshmen in 2009 • Trends in participation and performance in Advanced Placement program from 2002 to 2012 • High school Advanced Placement mathematics and science course offerings in 2012
Teachers of mathematics and science	• Experience, certification, and subject-matter preparation of mathematics and science teachers in 2012 • Professional development of mathematics and science teachers in 2012 • Working conditions of mathematics and science teachers in 2012 • Attrition rates of beginning public school teachers from 2007–08 to 2009–10
Instructional technology and digital learning	• Term definitions and review of emerging policies, practices, and the effects of instructional technology and distance education on student learning
Transitions to higher education	• Trends in on-time high school graduation rates from 2006 to 2010 • International comparisons of secondary school graduation rates in 2010 • Immediate college enrollment from 1975 to 2011 • Remedial coursetaking among 2003–04 beginning postsecondary students • International comparisons of college enrollment rates in 2010

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Monitoring Progress Toward Successful K–12 STEM Education

In 2011, the National Research Council (NRC 2011) articulated three goals for K–12 STEM education:

- ♦ Expand the number of students who ultimately pursue advanced degrees and careers in STEM fields and broaden the participation of women and minorities in those fields;
- ♦ Expand the STEM-capable workforce and broaden the participation of women and minorities in that workforce; and
- ♦ Increase science literacy for all students, including those who do not pursue STEM-related careers or additional study in the STEM disciplines.

The NRC concluded that realizing these goals would require changing the way that STEM subjects are taught. Accordingly, the NRC recommended that the United States needs to systematically monitor national progress toward achieving these goals and commissioned a group of experts to develop indicators that, taken together, could constitute a viable monitoring system. This system will be based on recommendations from national reports that provide evidence supporting "best practices." The NRC recently released a report that identifies 14 indicators for monitoring progress in STEM teaching and learning (NRC 2012b). Once fully developed, this system of indicators will measure student knowledge, interest, and participation in the STEM disciplines and STEM-related activities; track financial, human capital, and material investments in K–12 STEM education at the federal, state, and local levels; provide information about the capabilities of the STEM education workforce, including teachers and principals; and facilitate strategic planning for federal investments in STEM education and workforce development when used with labor force projections.

Working closely with the U.S. Department of Education, NSF has also undertaken several activities to build the proposed system of indicators. These activities include the following:

- ♦ Determining what data and data collection vehicles currently exist that could be used or modified to enable these indicators to be tabulated and reported;
- ♦ Fully developing operational definitions of the proposed new indicators; and
- ♦ Engaging stakeholders in the STEM policy community and experts in the collection of national statistical data to identify the best methods to collect these data.

a snapshot of kindergarten students' status as they enter school, including baseline measures of their mathematics and science performance. This section then covers elementary and secondary students' performance on standardized mathematics and science assessments, focusing on recent trends in student performance, changes in performance gaps among different groups, and the international standing of U.S. students vis-à-vis their peers abroad.

The second section focuses on mathematics and science coursetaking in high school. It begins by examining ninth graders' enrollment in mathematics and science courses, providing information on what courses students take as they enter high school. The section then uses data from the College Board to examine trends in participation and performance in the STEM-related Advanced Placement (AP) programs among high school graduating classes. High school course completion data from the most recent transcript studies were reported in the 2012 edition of *Science and Engineering Indicators*; no new course completion data were available for this volume. Therefore, this section is somewhat limited because of fewer data.

The third section turns to U.S. elementary, middle, and high school mathematics and science teachers in 2012, examining their experience, licensure, subject matter preparation, professional development, and working conditions. In addition, this section presents new data on beginning mathematics and science teachers' attrition in the first 3 years of teaching.

The fourth section examines how technology is used as an instructional tool in K−12 education. In the absence of nationally representative data, this section mainly provides a literature review, focusing on term definitions, emerging policies and practices, and the latest research findings on the effects of instructional technology and distance education on student learning in mathematics and science.

The last section presents indicators of student 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. This section also includes data on remedial coursetaking by beginning postsecondary students, an indicator of the extent to which secondary schools prepare entering students for college-level work.

This chapter focuses primarily on national patterns and trends, but it also discusses variation in student performance or access to educational resources by demographic, family, and school characteristics.[3] Because of the unavailability of national data, this chapter cannot report indicators for many other activities that are important to understanding K−12 STEM education, such as use of high-quality mathematics and science curricular materials, time spent on mathematics and science learning, participation in STEM-related activities outside of school, and interest in pursuing a STEM degree and career. In addition, certain measures in this chapter may not capture the full dimension of the construct being examined (e.g., family poverty is determined by students' eligibility for free/reduced-price lunch instead of being calculated directly from family income). These limitations may impede providing a full picture of STEM education at the K−12 level.

Student Learning in Mathematics and Science

Increasing overall student achievement, especially lifting the performance of low achievers, is an essential goal of education reform in the United States. Reform efforts center on improving student learning in mathematics and science because these fields are widely regarded as critical to the nation's economy (Atkinson and Mayo 2010; President's Council of Advisors on Science and Technology 2012). This section presents indicators of U.S. student performance in mathematics and science, beginning with a snapshot of the mathematics and science test scores of a recent cohort of U.S. kindergartners. It then presents long-term trends in the mathematics and science performance of U.S. fourth and eighth graders,[4] examining more than two decades of changes in overall performance and in gaps between different groups. The section ends by placing U.S. student performance in an international context, comparing U.S. fourth and eighth graders' mathematics and science test scores with those of their peers in other nations.

Mathematics and Science Performance During the Kindergarten Year

The Early Childhood Longitudinal Study, Kindergarten Class of 2010−11 (ECLS-K:2011) is a nationally representative, longitudinal study of children's development, early learning, and school progress (Mulligan, Hastedt, and McCarroll 2012). The study began with approximately 18,200 children in kindergarten in fall 2010 and will follow and test them every year until spring 2016, when most of them are expected to be in fifth grade. The study gathers information from many sources, including the students themselves, their families, teachers, schools, and before- and after-school care providers. These data provide a wealth of information on children's cognitive, social, emotional, and physical development; family and neighborhood environments; school conditions; and before- and after-school care. The longitudinal study design will enable research on how various family, school, community, and individual factors are associated with school performance over time. At the time this chapter was prepared, only data from the initial year of the study were available for analysis. This section, therefore, presents descriptive information on children when they enter school and their initial mathematics and science assessment results (mathematics and science assessment scores cannot be compared directly because scales are developed independently for each subject). This information will serve as a baseline for measuring students' progress on future assessments as they advance through elementary school. Findings from these assessments will be presented in future editions of *Science and Engineering Indicators*.

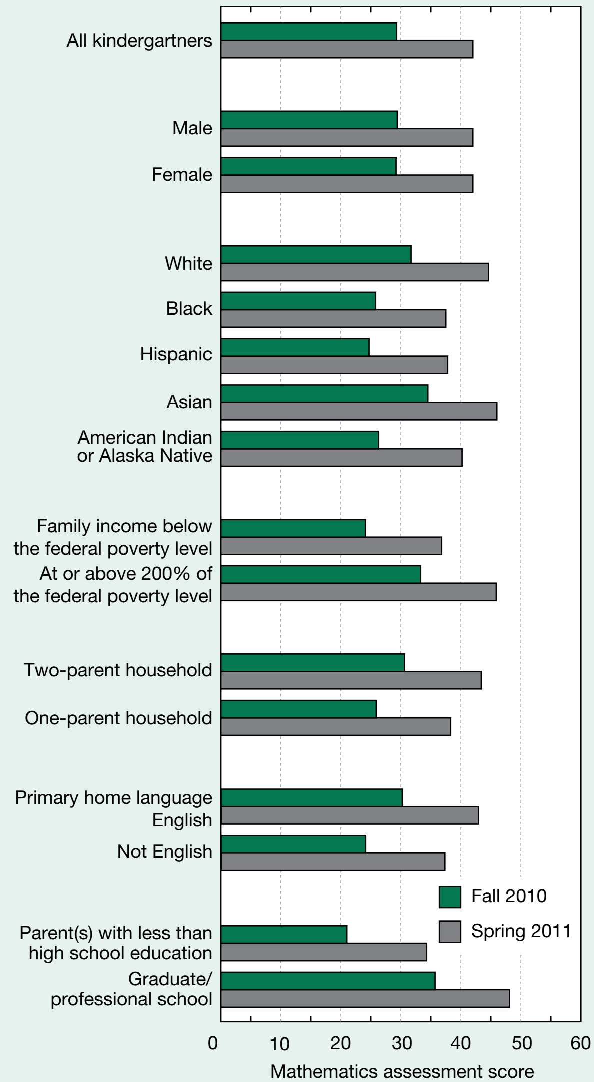
Demographic Profile of U.S. First-Time Kindergartners. In fall 2010, about 3.5 million U.S. children entered kindergarten for the first time (Mulligan, Hastedt, and McCarroll 2012). Students in this cohort came from diverse backgrounds: about two-fifths of kindergartners (38%) had at least one parent with a bachelor's degree or higher, 32% had parents who attended some college but did not earn a bachelor's degree, and 29% had parents with no more than a high school education (appendix table 1-1). About one-quarter of children were living in families with incomes below the federal poverty level (25%) or in single-parent households (22%). Fifteen percent of students came from families where the primary language used at home was not English. Nearly half (47%) were racial and ethnic minorities, with Hispanics being the largest minority group (24%), followed by blacks (13%) and Asians (4%).[5] The following analysis examines the size and direction of achievement differences among different groups at the outset of formal schooling.

Mathematics Performance.[6] Even as early as kindergarten, large gaps in mathematical understanding already exist among different subpopulations. Initial mathematics assessment scores varied by parental education level; for example, children whose parents had less than a high school education scored 15 points (on a scale of 0–75) below their peers whose parents attended a graduate or professional school (figure 1-1). Students from homes with a primary language other than English earned an average of 24 points on the initial mathematics test, compared with 30 points earned by those with a primary home language of English. Students from families with incomes below the federal poverty level scored 9 points below their peers from families with incomes at or above 200% of the federal poverty level. Those from single-parent households also did not perform as well as those from two-parent households (26 versus 31 points). The gaps were further evident among different racial and ethnic groups: black and Hispanic students lagged behind Asian students by 9 to 10 points and white students by 6 to 7 points.

By spring 2011, the overall average mathematics score of kindergartners had increased by 13 points, from 29 to 42, on the 0–75 scale (figure 1-1). All groups gained 12–13 points from fall 2010 to spring 2011. Although the performance gaps did not widen during this period, students' initial exposure to formal schooling did not help narrow these gaps either.

Science Performance. Overall, kindergartners earned an average of 11 points (on a scale of 0–20) on their initial science assessment administered several months after the beginning of the school year (appendix table 1-1). Like in mathematics, variations in science performance among kindergartners with different characteristics were evident at this early stage of schooling, and the pattern of variations was largely similar. For example, science assessment

Figure 1-1
Average mathematics assessment scores of first-time kindergartners, by child and family characteristics: Fall 2010 and spring 2011



NOTES: Mathematics assessment scores range from 0 to 75. Family's poverty level is based on 2010 U.S. Census poverty thresholds, which identify incomes determined to meet household needs given family size. For example, in 2010, a family of two was below the poverty threshold if its income was lower than $14,220. Parents' education is the highest level of education achieved by either of the parents or guardians in a two-parent household or by the only parent or guardian in a single-parent household. Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, and white refer to individuals who are not of Hispanic origin.

SOURCE: Mulligan GM, Hastedt S, McCarroll JC, *First-Time Kindergartners in 2010–11: First Findings From the Kindergarten Rounds of the Early Childhood Longitudinal Study, Kindergarten Class of 2010–11* (ECLS-K:2011), NCES 2012-049 (2012). See appendix table 1-1.

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scores increased with parental education level, with children whose parents had less than a high school education scoring 4 points below their peers whose parents attended a graduate or professional school (9 versus 13 points). Kindergartners from homes with a primary home language other than English earned an average of 9 points on the initial science assessment, compared with 12 points earned by those with a primary home language of English. Those from households with incomes below the federal poverty level also had lower scores than their peers from households with incomes at or above 200% of the federal poverty level (10 versus 13 points). Among all racial and ethnic groups, white children earned the highest average score (12 points), followed by American Indian or Alaska Native and Asian children (about 11 points for both groups); black and Hispanic children earned the lowest average score (about 10 points for both groups).

Large gaps in student performance at the beginning of formal schooling suggest that nonschool factors play a big role in these disparities. Although a body of research has attempted to identify various factors underlying students' achievement gaps, efforts have mostly focused on school-related factors such as teacher quality, available resources, principal leadership, and school climate, or such nonschool factors as sex, race and ethnicity, and family socioeconomic status (SES) (Coleman et al. 1966; Corcoran and Evans 2008; Fryer and Levitt 2004; Greenwald, Hedges, and Laine 1996; Hanushek and Rivkin 2006; Lamb and Fullarton 2002; Leonidas et al. 2010; OECD 2005; Rivkin, Hanushek, and Kain 2005). Researchers are now turning their attention to a broader range of nonschool factors beyond students' demographic and socioeconomic backgrounds, and probing deeper into their roles in student achievement (Henig and Reville 2011) (see sidebar, "The Role of Nonschool Factors in Student Learning").

Mathematics and Science Performance in Grades 4 and 8

The National Assessment of Educational Progress (NAEP), a congressionally mandated study, has monitored changes in U.S. students' academic performance in mathematics, science, and other subjects since 1969 (NCES 2011a, 2012). NAEP has two assessment programs: the main NAEP and the NAEP Long-Term Trend (LTT).[7] The main NAEP assesses national samples of fourth and eighth graders at regular intervals, and twelfth graders on an occasional basis. These assessments are updated periodically to reflect changes in curriculum standards. 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 three decades. This section examines recent performance results using the main NAEP data only. The most recent available findings based on NAEP LTT data have been reported in previous editions of *Science and Engineering Indicators*.[8]

Reporting Results for the Main NAEP

The main NAEP reports student performance in two ways: scale scores and achievement levels. Scale scores use a continuous scale to measure student learning. 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. Scores cannot be compared across subjects because NAEP scales are developed independently for each subject.

In addition to scale scores, NAEP reports student results in terms of achievement levels. Developed by the National Assessment Governing Board (NAGB), achievement levels are intended to measure the extent to which students' actual achievement matches the achievement expected of them. Based on recommendations from panels of educators, policymakers, and the general public, NAGB sets three achievement levels for mathematics (NAGB 2010a), science (NAGB 2010b), and other subjects assessed by NAEP:

- *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*.[9] Achievement levels cannot be compared across grade levels because they were developed independently at each grade level.[10] Although the NAEP achievement levels can be helpful in understanding and interpreting student results and have been widely used by national and state officials, there is ongoing disagreement about whether they are appropriately defined (Harvey 2011). A study commissioned by the National Academy of Sciences judged the NAEP achievement levels to be "fundamentally flawed" (Pellegrino, Jones, and Mitchell 1999). In addition, the National Mathematics Advisory Panel concluded that NAEP scores for the two highest achievement categories (proficient and advanced) were set too high (NMAP 2008). Because of criticisms like these, NCES has recommended that achievement levels be used on a trial basis and interpreted with caution (NCES 2011a, 2012). The following review of NAEP results reports both average scale scores and the percentage of students performing at or above the proficient level.

Mathematics Performance from 1990 to 2011

Average Score. The average mathematics score of U.S. fourth graders increased by 27 points from 1990 to 2007, leveled off between 2007 and 2009, and then rose by 1 point from 2009 to 2011 (figure 1-2). This overall trend was reflected in almost all demographic groups,[11] across students at all performance levels (i.e., 10th to 90th percentiles[12]), and among students at both public and private schools. For example, from 1990 to 2007, the fourth grade average mathematics score increased substantially—by 28 points for white students, 34 points for black students, 27 points for Hispanic students, and 28 points for Asian or Pacific Islander students (appendix table 1-2). Average scores for these racial and ethnic groups remained unchanged between 2007 and 2009 and then increased by 1 or 2 points from 2009 to 2011.

Among U.S. eighth graders, the average mathematics score increased continuously from 1990 to 2011, with a total gain of 21 points over the period (figure 1-2). Although the scores of all demographic groups have improved substantially since 1990, not all groups have experienced this upward trend in recent years. For example, the average mathematics scores for male students, whites, Asians or Pacific Islanders, American Indians or Alaska Natives, and those attending private schools remained unchanged between 2009 and 2011 (appendix table 1-2). Groups that experienced score gains during this period included black

The Role of Nonschool Factors in Student Learning

The major national studies of student academic performance include only partial data on nonschool factors that can affect student learning. Nonschool factors often available from the major national studies used in this chapter include student's demographic characteristics (e.g., sex and race and ethnicity) and family backgrounds (e.g., family income, parental education, and the primary home language). Other nonschool factors such as personality traits, health and nutrition, and neighborhood characteristics matter for learning as well, but they are relatively difficult to measure and therefore rarely covered in the national studies on education and student achievement.

Research on nonschool factors dates back to the 1966 release of the report *Equality of Educational Opportunity* (Coleman et al. 1966), which examined the interrelationships among race and ethnicity, family characteristics, and student achievement. The authors of this report concluded that students' socioeconomic background (measured by parents' income, occupation, and education) was a far more influential factor than were school-related factors. Since then, this line of research has evolved, adding such familial factors as household structure, immigrant status, the primary home language, parenting style, and parental involvement and support as having an impact on student achievement. The findings of this research are generally consistent: students from low-income families, those whose parents have lower levels of educational attainment or are uninvolved in their children's education, and those who live in a single-parent household or a home where the primary language spoken is not English generally do not perform as well as students from more advantaged backgrounds (Aud, Fox, and KewalRamani 2010; Berliner 2009; Campbell et al. 2008; Hampden-Thompson and Johnston 2006; Jeynes 2005; Kreider and Ellis 2011; Lareau 2011; Lee and Burkham 2002; Mulligan, Halle, and Kinukawa 2012; Pong, Dronkers, and Hampden-Thompson 2003; Rothstein 2004; Schmid 2001; Spera 2005; Stockton 2011). Research further indicates that differential access to high-quality preschool care and programs, which is highly related to parental income, is a contributing factor to initial academic achievement gaps (Camilli et al. 2010; Chambers et al. 2010; Flanagan and McPhee 2009).

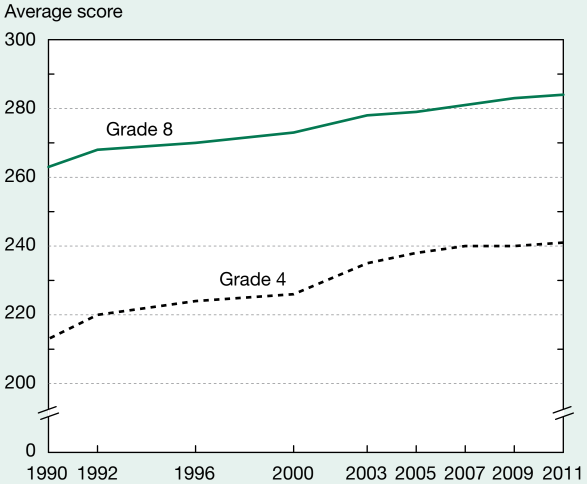
To attempt to explain more of the variation in student achievement, researchers also turned to personality traits, exploring whether and how attributes like perseverance, motivation, self-control, self-efficacy, and social skills contribute to students' academic achievement (Almlund et al. 2011; Bozick and Dempsey 2010; Dalton 2010; Duckworth et al. 2007; Heckman and Kautz 2012; Lennon 2010a, 2010b; McClelland, Acock, and Morrison 2006; Pintrich and de Groot 1990; Schunk 1981; Snyder 2001; Tough 2012; Walls and Little 2005; Webster-Stratton and Reid 2004). Though not conclusive, cumulative evidence points to persistence, motivation to learn and achieve, the ability to delay gratification and aim for long-term goals, belief in one's ability to accomplish academic tasks, and the ability to self-regulate and use self-control as being positively associated with achievement measures such as standardized test scores, grades, and high school completion.

Researchers have also examined the effects of health-related factors on student learning (Berliner 2009; Castelli et al. 2007; Chernoff et al. 2007; Conti, Heckman, and Urzua 2010; Daniels et al. 2005; Hack et al. 2002; Nihiser et al. 2007; Rothstein 2010; Stockton 2011). Low birth weight, unhealthy eating, malnutrition, environmental pollution, inadequate medical/dental/vision care, and exposure to stress and discord at home can induce a variety of physical, sociological, and psychological problems, ranging from neurological damage and attention disorders to excessive absenteeism, linguistic underdevelopment, and oppositional behavior. These problems, in turn, can adversely affect student learning outcomes.

Finally, the effects of children's home life on academic achievement can be influenced by neighborhood characteristics such as the unemployment rate, concentration of poverty, incidence of violence and gang activities, and rates of mobility and homelessness (Ainsworth 2002; Berliner 2009; Rothstein 2010). Research indicates that students living in impoverished or unsafe communities have a higher frequency of developmental and health problems than do those from more affluent or safe communities, even after controlling for family conditions, and those developmental and health problems, in turn, are associated with such academic outcomes as low test scores and dropping out of school (Arneshensal and Sucoff 1996; Brooks-Gunn et al. 1993; Catsambis and Beveridge 2001; Garner and Raudenbush 1991; Wickrama, Noh, and Bryant 2005).

female students (whose scores increased by 2 points), Hispanic male and female students (by 3 and 5 points, respectively), and low- or high-income students (by 2 and 3 points, respectively).[13]

Figure 1-2
Average NAEP mathematics scores of students in grades 4 and 8: 1990–2011



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 are for students allowed to use testing accommodations

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of NAEP 1990, 1992, 1996, 2000, 2003, 2005, 2007, 2009, and 2011 mathematics assessments, National Center for Education Statistics. See appendix table 1-2.

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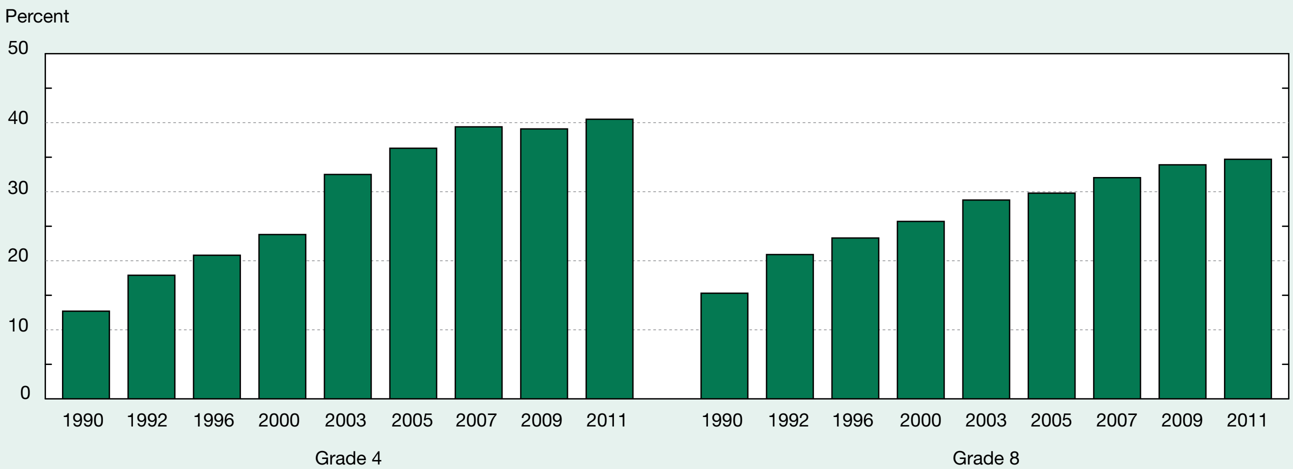
Achievement Level. Trends in the percentages of fourth and eighth graders reaching the proficient level parallel the scale score trends (figure 1-3). The percentage of fourth graders performing at or above the proficient level increased steadily through 2007 and essentially leveled off from 2009 to 2011. Eighth graders overall showed continuous improvement from 1990 to 2011, though the improvement did not persist for some groups during recent years (appendix table 1-3). Furthermore, despite overall upward trends, the actual percentage of students reaching the proficient level in mathematics remained well below half—in 2011, 40% of fourth graders and 35% of eighth graders performed at or above this level.

Science Performance from 2009 to 2011

In 2009, the framework for the main NAEP science assessment was significantly changed to reflect advances in science, curriculum standards, assessments, and research on science learning (NAGB 2010b). Because of these modifications, the results from the 2009 and 2011 assessments cannot be compared with those from the earlier assessments. Whereas the 2009 assessment included students in grades 4, 8, and 12, the 2011 assessment targeted students only in grade 8. This section, therefore, discusses the 2009 and 2011 assessment results for students in grade 8 only.[14]

Average Score. The average science score of eighth graders increased from 150 in 2009 to 152 in 2011 (figure 1-4).[15] With a few exceptions (Asian or Pacific Islander students, high-performing students [at the 90 percentile], and private school students), most demographic groups improved their science scores during this period, with score gains ranging from 1 point for female students and white students to 3

Figure 1-3
Students in grades 4 and 8 scoring at or above NAEP's proficient level in mathematics for their grade: 1990–2011



NAEP = National Assessment of Educational Progress.

NOTE: From 1996 on, data are for students allowed to use testing accommodations.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of NAEP 1990, 1992, 1996, 2000, 2003, 2005, 2007, 2009, and 2011 mathematics assessments, National Center for Education Statistics. See appendix table 1-3.

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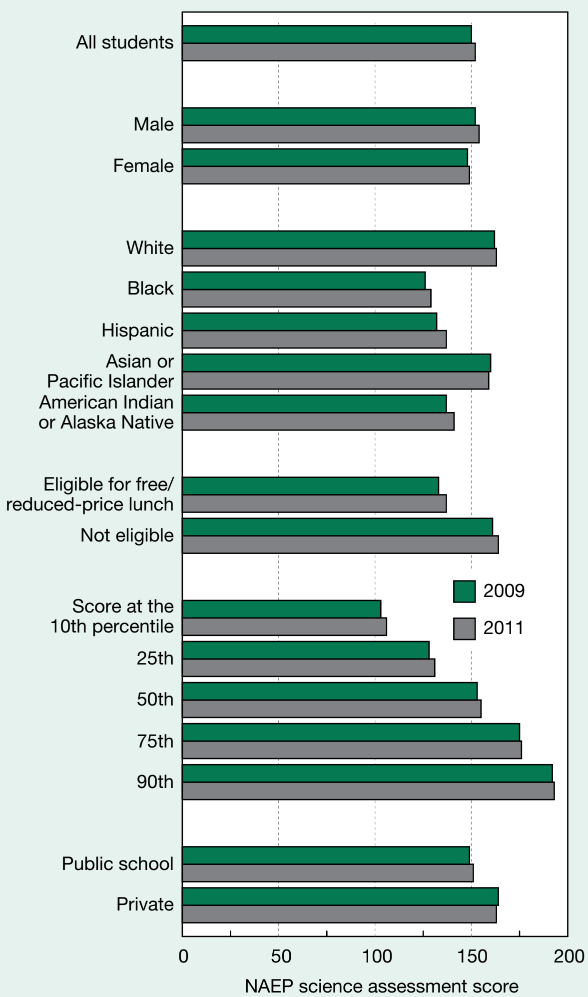
points for black students, 4 points for low-income students, and 5 points for Hispanic students (appendix table 1-4).

Achievement Level. Like scale scores, the percentage of eighth graders performing at or above the proficient level in science increased slightly from 30% in 2009 to 32% in 2011 (appendix table 1-5). Despite this improvement, the majority of students performed below the proficient level on the science assessment in both years. In 2011, for example, 68% of eighth graders failed to reach the proficient level in science. The percentage who scored below this level was especially high among black and Hispanic students (90% and 84%, respectively), particularly among female students in both groups (91% and 87%, respectively).

Figure 1-4
Average NAEP science scores of students in grade 8, by student and school characteristics: 2009 and 2011



NAEP = National Assessment of Educational Progress.

NOTES: NAEP science assessment scores range from 0 to 300 for grade 8. Scores for percentile rows are not averages but the actual scores that mark each percentile listed. For example, a score at the 10th percentile indicates that 10% of students perform at or below this score. Hispanic may be any race. American Indian or Alaska Native, black or African American, Asian or Pacific Islander, and white refer to individuals who are not of Hispanic origin.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of NAEP 2009 and 2011 science assessments, National Center for Education Statistics. See appendix table 1-4.

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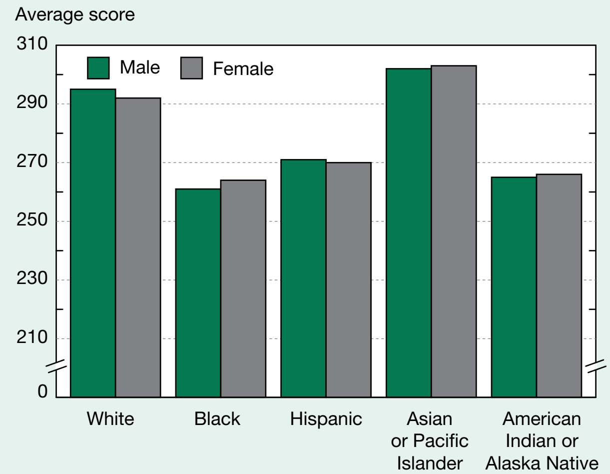
Changes in Performance Gaps in Mathematics and Science

Most performance gaps that existed in earlier years persisted in 2011, although none of these gaps have widened since 1990 (appendix tables 1-2 and 1-4). Overall, sex differences were small, with male students performing slightly better than female students in mathematics and science. Differences between male and female students, however, were not consistent across racial and ethnic groups. Although eighth grade white male students in 2011 had higher mathematics scores than their female counterparts (295 versus 292), similar sex differences were not observed among Hispanic, Asian or Pacific Islander, and American Indian or Alaska Native students (figure 1-5). Among black eighth graders, the gap was reversed: female students performed slightly better than male students (264 versus 261).

Large performance gaps existed among other groups. For both mathematics and science at grades 4 and 8, white and Asian or Pacific Islander students performed better than

Figure 1-5
Average NAEP mathematics scores of students in grade 8, by sex, race, and ethnicity: 2011



NAEP = National Assessment of Educational Progress.

NOTES: NAEP mathematics assessment scores range from 0 to 500 for grade 8. Hispanic may be any race. American Indian or Alaska Native, Asian or Pacific Islander, black or African American, and white refer to individuals who are not of Hispanic origin.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of NAEP 2011 mathematics assessments, National Center for Education Statistics. See appendix table 1-2.

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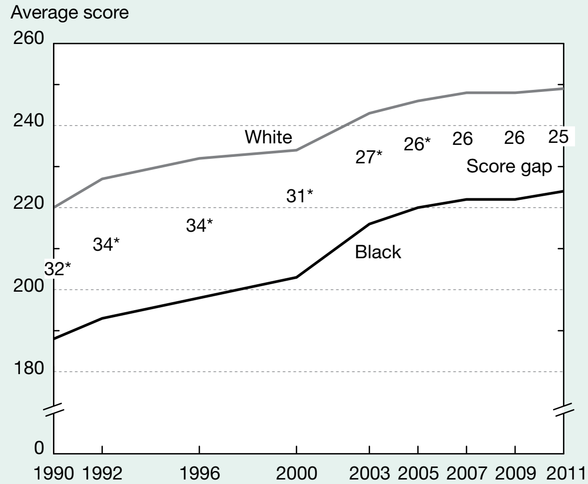
their black, Hispanic, or American Indian or Alaska Native counterparts (appendix tables 1-2 and 1-4). Students from higher-income families also had higher scores in mathematics and science than those from lower-income families. Gaps were observed by school type as well, with private school students scoring higher than public school students.[16]

Some gaps in mathematics and science scores have narrowed over time (table 1-2). In mathematics, gap reductions occurred among fourth grade students but not among eighth grade students. Specifically, the 32-point white-black gap in mathematics performance among fourth grade students decreased to 25 points between 1990 and 2011 because of larger gains by black students (figure 1-6). The reduction in the white-black gap occurred among both male and female fourth graders (table 1-2; appendix table 1-2). Further, the fourth graders' score at the 10th percentile rose more than did the score at the 90th percentile, reducing the gap between low- and high-performing students from 82 to 73 points between 1990 and 2011. None of these gap reductions was observed among eighth grade students, however.

In science, the eighth graders' average score increased more for black students (3 points) and Hispanic students (5 points) than for white students (1 point) between 2009 and 2011, narrowing the white-black gap (especially among male students) and the white-Hispanic gap (among both male and female students) (table 1-2; appendix table 1-4). Finally, the eighth graders' science score at the 10th percentile rose faster than that at the 90th percentile, reducing the gap between low- and high-performing students from 89 to 87 points.

Figure 1-6
Average NAEP mathematics scores and score gaps for white and black students in grade 4: 1990–2011



* = Gap between white and black students is significantly different from the 2011 gap.

NAEP = National Assessment of Educational Progress.

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

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of NAEP 1990, 1992, 1996, 2000, 2003, 2005, 2007, 2009, and 2011 mathematics assessments, National Center for Education Statistics. See appendix table 1-2.

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Table 1-2
Changes in NAEP mathematics and science score gaps between selected groups of students in grades 4 and 8: 1990–2011

	Change in score gap		
	Grade 4 mathematics	Grade 8 mathematics	Grade 8 science
Score gap between selected groups of students	1990–2011	1990–2011	2009–11[a]
Males and females	≈	≈	≈
Whites and blacks	↓	≈	↓
White males and black males	↓	≈	↓
White females and black females	↓	≈	≈
Whites and Hispanics[b]	≈	≈	↓
White males and Hispanic males	≈	≈	↓
White females and Hispanic females	≈	≈	↓
Students from low-income families and those from other families[c]	≈	≈	≈
Low-performing students and high-performing students[d]	↓	≈	↓
Public school students and private school students	≈	≈	≈

≈ = no change; ↓ = decrease.

NAEP = National Assessment of Educational Progress.

[a] Changes in science score gaps for grade 8 are presented only for 2009–11 because prior assessments were not comparable with those in or after 2009.
[b] Hispanic may be any race.
[c] Information on student eligibility for subsidized lunch program, a measure of family poverty, was first collected in 1996. Changes in mathematics score gaps in 1990–2011 columns cover 1996–2011.
[d] Gap between students who scored at the 10th and 90th percentiles.

NOTE: From 1996 on, students were allowed to use testing accommodations.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of NAEP 1990, 1996, and 2011 mathematics assessments and of NAEP 2009 and 2011 science assessments, National Center for Education Statistics. See appendix tables 1-2 and 1-4.

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International Comparisons of Mathematics and Science Performance

Two international assessments—the Trends in International Mathematics and Sciences Study (TIMSS) and the Program for International Student Assessment (PISA)—compare U.S. students' achievement in mathematics and science with that of students in other countries. These two assessments differ in several fundamental ways, including the purpose of the study, age of the students tested, test content, and the number of participating nations.[17] Targeting students in grades 4 and 8 regardless of their age, the TIMSS tests focus on students' application of skills and knowledge to tasks akin to those encountered in school. The PISA tests, in contrast, assess the abilities of 15-year-olds to apply mathematics and science skills and information to solve real problems they may face at work or in daily life. This section compares the mathematics and science performance of U.S. students with that of their counterparts in other countries using assessment data from the latest administration of TIMSS (2011). No new data from PISA were available for this volume. The most recent PISA results showed that U.S. 15-year-olds did not perform as well as their peers in many developed countries. In 2009, the U.S. average score ranked 18th in mathematics and 13th in science out of 34 Organisation for Economic Co-operation and Development (OECD) nations participating in the assessment.[18]

First conducted in 1995, TIMSS assesses the mathematics and science performance of fourth and eighth graders every 4 years. TIMSS has been administered five times, most recently in 2011. Over 20,000 students in more than 1,000 schools across the United States took the assessment in spring 2011, joining almost 500,000 other students from 62 countries and jurisdictions (Provasnik et al. 2012).

TIMSS is designed to test students' knowledge of specific mathematics and science topics that are closely tied to the curricula of the participating education systems (Mullis et al. 2009). The assessment framework includes two dimensions: a content domain for the subject matter to be assessed within mathematics and science and a cognitive domain for the skills (e.g., knowing, applying, and reasoning) expected of students as they learn the mathematics or science content. Specifically, the content domain for fourth and eighth grade mathematics and science in TIMSS 2011 includes the following topics (see sidebar, "TIMSS 2011 Sample Items"):

TIMSS 2011 Sample Items

Sample for grade 4 mathematics:

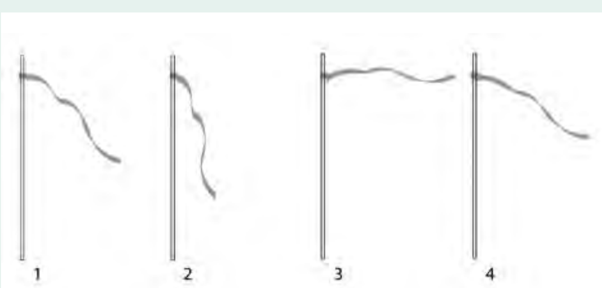
A shelf is 240 cm long. Chris is putting boxes on the shelf. Each box takes up 20 cm of shelf space. Which of these number sentences shows how many boxes Chris can fit on the shelf?

A. 240 – 20 C. 240 + 20
B. 240 ÷ 20 D. 240 x 20

Answer: B.

Sample for grade 4 science:

A ribbon is tied to a pole to measure the wind strength as shown below.



Write the numbers 1, 2, 3, and 4 in the correct order that shows the wind strength from the strongest to weakest.

Answer: 3, 4, 1, 2

Sample for grade 8 mathematics:

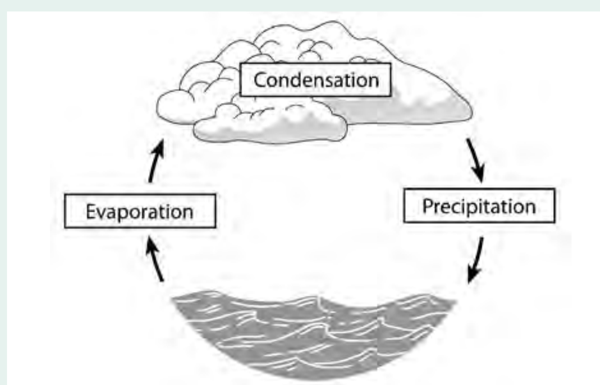
Which of these is equal to 2(x+y) – (2x-y)?

A. 3y C. 4x + 3y
B. y D. 4x + 2y

Answer: A

Sample for grade 8 science:

The diagram below shows Earth's water cycle.



What is the source of energy for the water cycle?

A. The Moon C. The tides
B. The Sun D. The wind

Answer: B

The above math and science sample questions come directly from http://timssandpirls.bc.edu/timss2011/downloads/TIMSS2011_Frameworks.pdf.

Mathematics

- ♦ Number, Geometric Shapes and Measures, Data Display (Grade 4)
- ♦ Number, Algebra, Geometry, Data and Chance (Grade 8)

Science

- ♦ Life Science, Physical Science, Earth Science (Grade 4)
- ♦ Biology, Chemistry, Physics, Earth Science (Grade 8)

Within each topic in the content domain, students are assessed on several skills, including their knowledge of facts, concepts, and procedures; application of those facts, concepts, and procedures to solve problems; and reasoning (i.e., solving unfamiliar, complex, or multistep problems). Although the content differs for fourth and eighth graders, reflecting the nature and difficulty of the mathematics and science taught at each grade, the cognitive domain is the same for both grade levels and subjects. A more detailed discussion of the framework for the TIMSS 2011 mathematics and science assessments can be found at http://timssandpirls.bc.edu/timss2011/downloads/TIMSS2011_Frameworks.pdf.

Mathematics Performance of U.S. Students in Grades 4 and 8 on TIMSS

Performance on the 2011 TIMSS Mathematics Tests. The U.S. average score on the 2011 TIMSS mathematics assessment was 541 at grade 4 and 509 at grade 8 (figure 1-7). Both scores were higher than the international TIMSS average, which is set to 500 at both grades.[19] Among 50 countries/jurisdictions that participated in the 2011 TIMSS mathematics assessment at grade 4, the U.S. average mathematics score was among the top 13 (seven scored higher; five did not differ), outperforming 37 countries/jurisdictions (appendix table 1-6).[20] The top scorers—Singapore, Republic of Korea, and Hong Kong (China)—each had average scores above 600.

At grade 8, the U.S average mathematics score was below the scores of six countries/jurisdictions, not different from the scores of seven, and higher than those of 28, placing the United States among the top 14 in eighth grade mathematics. The average scores of students in the Republic of Korea, Singapore, and Taipei[21] (the top three leaders) were at least 100 points higher than the average score of U.S. eighth graders (609–613 versus 509).

Performance Trends. Over the 16 years since the first TIMSS mathematics administration in 1995, U.S. fourth and eighth graders raised their scores and international ranking.[22] At grade 4, the average mathematics score of 541 in 2011 was 23 points higher than the score of 518 in 1995 (figure 1-8). Not only did U.S. fourth graders' mathematics scores increase but also the U.S. position relative to other nations climbed from 1995 to 2011. Among the 17 countries that participated in both the 1995 and 2011 TIMSS mathematics assessment of fourth graders, 7 outscored the United States in 1995 compared with 4 in 2011 (Provasnik et al. 2012).

Figure 1-7
Average TIMSS mathematics scores of students in grades 4 and 8, by country/jurisdiction: 2011

	Grade 4	Grade 8
Score higher than United States	Singapore 606 Republic of Korea 605 Hong Kong (China) 602 Taipei (Taiwan) 591 Japan 585 Northern Ireland 562 Belgium (Flemish) 549	Republic of Korea 613 Singapore 611 Taipei (Taiwan) 609 Hong Kong (China) 586 Japan 570 Russian Federation 539
Score not statistically different from United States	Finland 545 England 542 Russian Federation 542 **United States 541** Netherlands 540 Denmark 537	Israel 516 Finland 514 **United States 509** England 507 Australia 505 Hungary 505 Slovenia 505 Lithuania 502
Score lower than United States (selected countries)	Lithuania 534 Portugal 532 Germany 528 Ireland 527 Australia 516 Serbia 516 Hungary 515 Slovenia 513 Czech Republic 511 Austria 508	Italy 498 New Zealand 488 Kazakhstan 487 Sweden 484 Ukraine 479 Norway 475 Armenia 467 Romania 458 United Arab Emirates 456 Turkey 452

TIMSS = Trends in International Mathematics and Science Study.

NOTES: Hong Kong is a Special Administrative Region of the People's Republic of China. Taipei is the capital city of Taiwan. Countries/jurisdictions are ordered by 2011 average score. Countries/jurisdictions with identical rounded estimates are listed alphabetically.

SOURCE: Provasnik S, Kastberg D, Ferraro D, Lemanski N, Roey S, Jenkins F, *Highlights From TIMSS 2011: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context*, NCES 2013-009 (2012). See appendix table 1-6.

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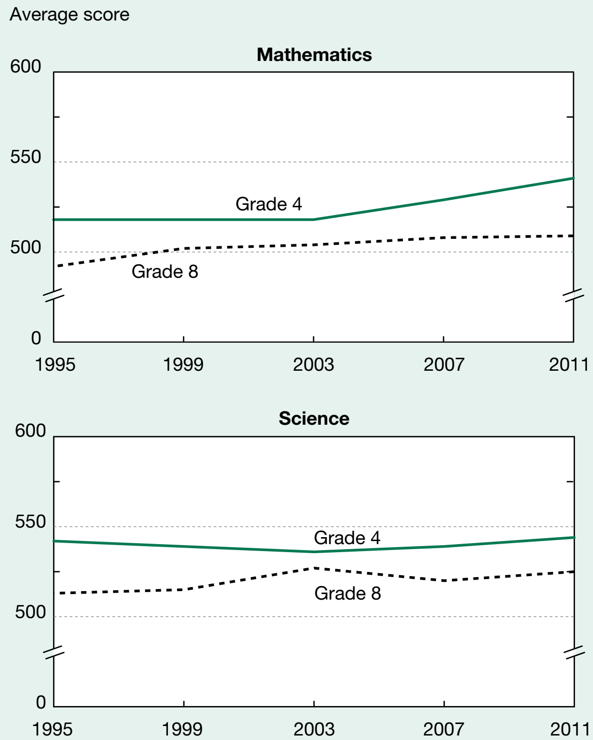
At grade 8, the U.S. average score of 509 in 2011 reflected a 17-point increase over the 1995 score (492) (figure 1-8). The relative standing of U.S eighth graders' mathematics performance has also improved over this time period: among the 16 countries that participated in both the 1995 and 2011 TIMSS mathematics assessment of eighth graders, 5 outperformed the United States in 2011, down from 8 in 1995 (Provasnik et al. 2012).

Science Performance of U.S. Students in Grades 4 and 8 on TIMSS

Performance on the 2011 TIMSS Science Tests. In 2011, the average science scores of both U.S. fourth and eighth grade students (544 and 525, respectively) were higher than the international TIMSS scale average (500) (figure 1-9). At grade 4, the United States was among the top seven countries/jurisdictions, outperforming 43 among a total of 50 participants (appendix table 1-7). Students in Republic of Korea, Singapore, Finland, Japan, Russian Federation,

Figure 1-8
Average TIMSS mathematics and science scores of U.S. students in grades 4 and 8: 1995–2011



TIMSS = Trends in International Mathematics and Science Study.

NOTES: TIMSS mathematics and science assessment scores range from 0 to 1,000 for grades 4 and 8. U.S. fourth graders did not participate in TIMSS in 1999; score is interpolated. Average mathematics and science scores of students in grade 4 and grade 8 cannot be compared directly because the test items differ across grade levels to reflect the nature, difficulty, and emphasis of the subject matter taught in school at each grade.

SOURCES: Gonzales P, Williams T, Jocelyn L, Roey S, Kastberg D, Brenwald S, *Highlights From TIMSS 2007: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context*, NCES 2009-001 (2008); Provasnik S, Kastberg D, Ferraro D, Lemanski N, Roey S, Jenkins F, *Highlights From TIMSS 2011: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context*, NCES 2013-009 (2012).

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Figure 1-9
Average TIMSS science scores of students in grades 4 and 8, by country/jurisdiction: 2011

	Grade 4	Grade 8
Score higher than United States	Republic of Korea....587 Singapore ....583 Finland....................570 Japan.....................559 Russian Federation ....552 Taipei (Taiwan) 552	Singapore ....590 Taipei (Taiwan) ....564 Republic of Korea.....560 Japan.......................558 Finland ....552 Slovenia...................543 Russian Federation...542 Hong Kong (China) 535
Score not statistically different from United States	**United States 544**	England ....533 **United States ....525** Hungary...................522 Australia...................519 Israel........................516
Score lower than United States (selected countries)	Czech Republic ...... 536 Hong Kong (China) .... 535 Hungary................. 534 Sweden .... 533 Austria .... 532 Slovak Republic...... 532 Netherlands .... 531 England .... 529 Denmark .... 528 Germany................ 528	Lithuania..................514 New Zealand ....512 Sweden ....509 Italy..........................501 Ukraine ....501 Norway ....494 Kazakhstan..............490 Turkey......................483 Islamic Republic of Iran ....474 Romania 465

TIMSS = Trends in International Mathematics and Science Study.

NOTES: Hong Kong is a Special Administrative Region of the People's Republic of China. Taipei is the capital city of Taiwan. Countries/jurisdictions are ordered by 2011 average score. Countries/jurisdictions with identical rounded estimates are listed alphabetically.

SOURCE: Provasnik S, Kastberg D, Ferraro D, Lemanski N, Roey S, Jenkins F, *Highlights From TIMSS 2011: Mathematics and Science Achievement of U.S. Fourth- and Eighth-Grade Students in an International Context*, NCES 2013-009 (2012). See appendix table 1-7.

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and Taipei outscored students in the United States (552–587 versus 544). At grade 8, the U.S. average science score of 525 was lower than those of 8 countries/jurisdictions, higher than those of 29, and not measurably different from those of the remaining 4.

Performance Trends. In contrast to the mathematics trends, which showed significant improvement in both grades, the average scores of U.S. students on the TIMSS science assessment have remained flat since 1995 for fourth graders and improved 12 points for eighth graders (figure 1-8). U.S. fourth and eighth graders have not improved their international position. Among 17 countries and jurisdictions that participated in both the 1995 and 2011 fourth grade TIMSS science assessments, 3 outscored the United States in 2011 compared with 2 in 1995; at grade 8, the number scoring higher than the United States was 6 in both years (Provasnik et al. 2012).

Student Coursetaking in Mathematics and Science

Mathematics and science coursetaking in high school is a strong predictor of students' overall educational success. Students who take advanced mathematics and science courses in high school are more likely to earn high scores on academic assessments, enroll in college, pursue mathematics and science majors, and complete a bachelor's degree (Bozick and Lauff 2007; Chen 2009; NCES 2010, 2011b; Nord et al. 2011). Advanced coursetaking in high school is also associated with greater labor market returns and higher job satisfaction, even when controlling for demographic characteristics and postsecondary education and attainment (Altonji, Blom, and Maghir 2012; NRC 2012c). Analysis of the NAEP High School Transcript Study (NAEP HSTS) showed that the percentage of students earning credits for mathematics and science courses has increased steadily since 1990, though gaps among different groups of students remain (NSB 2012).[23] This section draws on data from the High School Longitudinal Study of 2009 (HSLS:09) and the College Board's AP program to augment earlier findings on mathematics and science coursetaking in high school, advanced coursetaking, and differences in coursetaking among various demographic groups. The section begins with contextual information about programmatic efforts to increase mathematics and science coursetaking and to standardize the quality of these courses. This information informs the interpretation of ninth grade coursetaking patterns found in the HSLS data.

High School Graduation Requirements and Curriculum Standards

Government and education leaders from 35 states participate in the American Diploma Project (ADP), which seeks to improve student achievement by aligning high school academic content standards with the demands of college and careers and requiring all graduating students to have completed a college- and career-ready curriculum (Achieve 2012). ADP encourages states and school districts to adopt graduation benchmarks that align high school coursework with the expectations of colleges and employers. The ADP graduation benchmarks suggest that for students to be considered ready for college and career, all students should complete 4 years of mathematics coursework at least through the level of pre-calculus.[24] In science, students should complete at least 3 years of coursework, including biology, chemistry, and physics. Currently, 23 states and the District of Columbia have adopted these graduation requirements (Achieve 2012). Two reform efforts, the Common Core State Standards Initiative (CCSSI) and the Next Generation Science Standards, focus on the content of the courses that students take rather than the number or level of courses. The goal of these efforts is to ensure that academic standards across states are similar and include the rigorous content and higher-order skills necessary to prepare all students for college and careers (see sidebar, "Common Core State Standards and Next Generation Science Standards").

Common Core State Standards and Next Generation Science Standards

To provide a clear and consistent framework of the skills and knowledge students must master in grades K−12, the National Governors Association (NGA) Center for Best Practices, the Council of Chief State School Officers (CCSSO) and Achieve Inc. coordinated a state-led effort to develop the Common Core State Standards (CCSS) in English language arts and mathematics (NGA/CCSSO 2010). The standards aim to ensure that all students have "the academic knowledge and skills in literacy and mathematics needed to qualify for and succeed in entry-level, credit-bearing postsecondary coursework or postsecondary job training" (Achieve 2012).

The CCSS were developed through a rigorous drafting and review process involving three workgroups (NGA/CCSSO 2010). One workgroup, composed of experts in assessment, curriculum design, cognitive development, and child development, drafted the standards. A second group, including business representatives and classroom educators as well as scholars, revised that draft, and a validation committee of education scholars, teachers, and other experts evaluated the final draft. Leaders of the initiative then solicited opinions from other experts who had not been consulted in earlier stages and released this draft for public comment. The standards writers reviewed the nearly 10,000 comments from the public and revised the standards before the final version was published in June 2010. As of August 2013, 45 states and the District of Columbia have formally adopted the CCSS (http://www.corestandards.org).

In a recent survey, school superintendents agreed that the CCSS are more rigorous than previous standards and will improve students' English language arts and math skills (Kober and Rentner 2012). The superintendents also noted that implementing the CCSS will require substantial changes in curriculum and instruction. Whereas the majority of the participating states hoped to implement the standards fully by the 2014−15 school year, many superintendents expressed concern about having sufficient resources for such large-scale change. To assist implementation efforts, two state consortia, the Partnership for Assessment of Readiness for College and Careers and Smarter Balanced Assessment, received federal grants to create assessment systems based on the standards. Both consortia will administer these assessments in 2014−15.

In addition to the CCSS in English language arts and mathematics, Achieve Inc. has worked with the National Research Council (NRC), the National Science Teachers Association, the American Association for the Advancement of Science, and 26 states to develop K−12 science standards (http://nextgenscience.org). The Next Generation Science Standards (NGSS) are based on the *Framework for K−12 Science Education*, which identifies broad ideas and practices in the natural sciences and engineering that all students should be familiar with by the time they graduate from high school (NRC 2012a). Following a rigorous development and review process for the NGSS, similar to that followed for the mathematics and English language arts standards, science educators and experts released an initial draft, which they revised substantially after receiving public comments. The final draft was released in April 2013, and states are now considering adoption of the standards.

Ninth Grade Mathematics and Science Coursetaking

HSLS:09 provides detailed data about student coursetaking in mathematics and science in ninth grade.[25] Based on a nationally representative sample of approximately 24,000 ninth graders in 944 schools, it focuses on understanding students' trajectories from the beginning of high school into higher education and the workforce (Ingels et al. 2011). HSLS:09 includes a heightened focus on STEM coursetaking and the high school and personal factors that lead students into and out of STEM fields of study and related careers. The data reported here are based on the base year of the study, conducted in fall 2009 when participants were in the ninth grade.[26] The base year supplies data about the mathematics and science courses that ninth graders took and about variations in their coursetaking by such factors as race and ethnicity, parental education level, and SES. The data are based on students' self-report of what mathematics and science courses they enrolled in at the beginning of ninth grade, not on evidence that they successfully completed the courses.

Mathematics Coursetaking

Algebra 1 is considered a "gateway" course leading to more advanced coursetaking in mathematics and to higher levels of achievement (Loveless 2008; Tierney et al. 2009). An expert panel convened by the Institution of Education Sciences to advise high schools on how to prepare students for college recommended that at a minimum all students should pass algebra 1 by the end of their ninth grade year (Tierny et al. 2009). The HSLS data indicate that the majority of students (81%) who were ninth graders in 2009 (the graduating class of 2012) were on track to meet this benchmark (table 1-3; appendix table 1-8), with 52% reporting enrollment in algebra 1 and 29% reporting enrollment in a more advanced math course than algebra 1, such as geometry 1 or algebra 2.[27] About 20% of students were not on track to meet this benchmark, however, with 9% reporting enrollment in basic mathematics or pre-algebra and 10% reporting no enrollment in any mathematics course. Research suggests that students who do not take any mathematics in ninth grade may suffer long-term consequences in terms of their educational success in high school and their entry into college or the workforce (Aughinbaugh 2012; Finkelstein et al. 2012; Long, Conger, and Iatarola 2012).

The percentage of students taking coursework above the level of algebra 1 in ninth grade (29%) indicates that many students are taking this course before reaching high school. These self-reported data are in line with NAEP transcript data (reported in the 2012 *Science and Engineering Indicators*), which indicated that 26% of high school graduates took algebra 1 before high school in 2009, up from 20% in 2005

Table 1-3
Highest-level mathematics course in which ninth graders enrolled, by student and family characteristics: 2009
(Percent distribution)

Student and family characteristic	No mathematics	Basic mathematics/ pre-algebra[a]	Algebra 1	Above algebra 1[b]
All grade 9 students	10.3	9.0	52.1	28.7
Sex				
Male	11.1	9.2	51.7	28.0
Female	9.5	8.8	52.4	29.3
Race or ethnicity				
Asian	7.3	6.6	28.1	58.0
Black	14.1	11.4	56.0	18.5
Hispanic[c]	13.3	8.9	53.1	24.8
White	8.4	8.6	51.6	31.4
Other[d]	9.3	8.7	55.5	26.6
Parents' highest education[e]				
Less than high school	18.4	12.6	46.8	22.2
High school diploma or equivalent	11.9	10.7	55.5	21.9
Associate's degree	8.5	8.9	59.7	22.9
Bachelor's degree	7.1	5.4	46.8	40.7
Master's degree or higher	5.1	4.0	39.8	51.1

[a] Basic mathematics includes review/remedial mathematics.
[b] Above algebra 1 includes geometry 1, algebra 2, trigonometry, integrated math 2, statistics, analytic geometry, and calculus.
[c] Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, Native Hawaiian or Other Pacific Islander, white, and more than one race refer to individuals who are not of Hispanic origin.
[d] Other includes Alaska Native, American Indian, Native Hawaiian, Pacific Islander, and more than one race.
[e] The highest level of education achieved by either parent.

NOTE: Detail may not sum to total due to rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of High School Longitudinal Study of 2009 (HSLS:09), National Center for Education Statistics. See appendix table 1-8.

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(NSB 2012). NAEP HSTS data show that nearly two-thirds of graduates who completed a rigorous high school curriculum took algebra 1 before high school (Nord et al. 2011).[28]

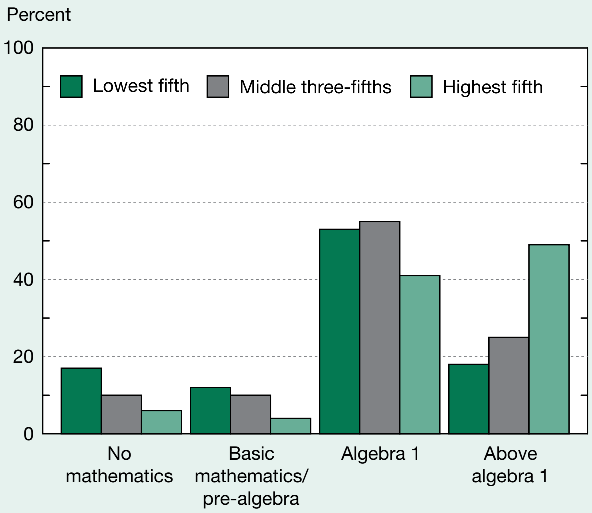
The percentage of students reporting enrollment in courses above algebra 1 varied by parental education level, SES,[29] and race and ethnicity. Students who had at least one parent with a master's degree or higher were most likely to report enrollment in a mathematics course above algebra 1 (51%), followed by students with at least one parent with a bachelor's degree (41%). About 22% of students with parents at all other education levels (associate's degree, high school diploma, and less than high school) reported enrolling in courses above algebra 1, with no significant difference among students with parents at these education levels. Nearly 50% of students in the highest SES quintile reported taking a course above algebra 1 compared with just 18% of students in the lowest SES quintile (figure 1-10). Asian students were more likely to report enrollment in courses above algebra 1 (58%) compared with white (31%), Hispanic (25%), and black (19%) students (table 1-3).

At the other end of the spectrum are students who reported no mathematics enrollment in ninth grade: 18% of students whose parents had less than a high school education reported no mathematics enrollment compared with 7% of students who had at least one parent with a bachelor's degree (table 1-3). About 17% of students in the lowest SES quintile reported no mathematics enrollment compared with 6% of those in the highest SES quintile (figure 1-10).

Science Coursetaking

Biology is the most common science subject students take in ninth grade: nearly 4 in 10 students in ninth grade (39%) reported enrollment in biology 1 (table 1-4; appendix table 1-9). About 7% reported enrollment in a science course above the level of biology 1, such as chemistry 1 or physics 1. A total of 18% of ninth graders reported no science enrollment, about twice the total of students reporting no mathematics enrollment (10%). Science coursetaking also varied by parental education level, SES, and race and ethnicity, showing similar patterns to those reported in mathematics.[30] The largest differences were in the percentage of students who reported no science enrollment. More than one-fourth of students in the lowest SES quintile (27%) reported no science enrollment compared with 11% of students in the highest SES quintile (figure 1-11). Proportionally more students who had parents with less than a high school education reported no science enrollment than did students who had at

Figure 1-10
Highest-level mathematics course in which ninth graders enrolled, by socioeconomic quintile: 2009



NOTES: Basic mathematics includes review/remedial mathematics. Above algebra 1 includes geometry 1, algebra 2, trigonometry, integrated math 2, statistics, analytic geometry, and calculus. Socioeconomic status (SES) is a composite variable derived from parental education level, parental occupation, and family income. The quintile measure divides the SES distribution into five equal groups. Quintile 1 corresponds to the lowest one-fifth of the population, and quintile 5 corresponds to the highest. For this report, the middle three quintiles are combined to form one category.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of High School Longitudinal Study of 2009 (HSLS:09), National Center for Education Statistics. See appendix table 1-8.

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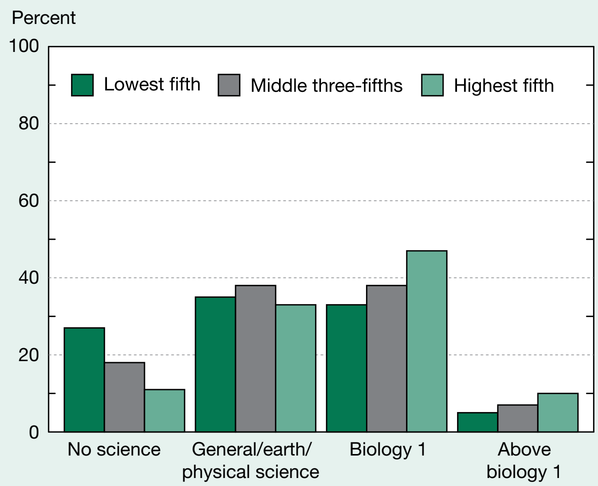
Figure 1-11
Highest-level science course in which ninth graders enrolled, by socioeconomic quintile: 2009



NOTES: Above biology 1 includes chemistry 1, physics 1, biology 2, Advanced Placement/International Baccalaureate (AP/IB) biology, chemistry 2, AP/IB chemistry, physics 2, and AP/IB physics. Socioeconomic status (SES) is a composite variable derived from parental education level, parental occupation, and family income. The quintile measure divides the SES distribution into five equal groups. Quintile 1 corresponds to the lowest one-fifth of the population, and quintile 5 corresponds to the highest. For this report, the middle three quintiles are combined to form one category.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of High School Longitudinal Study of 2009 (HSLS:09), National Center for Education Statistics. See appendix table 1-9.

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Table 1-4
Highest-level science course in which ninth graders enrolled, by student and family characteristics: 2009
(Percent distribution)

Student and family characteristic	No science	General science	Earth/ environmental/ physical science	Biology 1	Above biology 1[a]
All grade 9 students	18.0	5.1	31.2	38.7	7.0
Sex					
Male	18.9	5.1	31.3	38.0	6.7
Female	17.0	5.2	31.1	39.4	7.3
Race or ethnicity					
Asian	12.9	5.4	16.7	51.2	13.9
Black	25.2	5.5	27.2	35.1	7.0
Hispanic[b]	22.1	3.9	23.1	43.9	7.1
White	15.0	5.2	36.7	36.7	6.4
Other[c]	16.2	6.9	31.2	37.9	7.8
Parents' highest education[d]					
Less than high school	29.3	5.2	23.8	38.4	3.3
High school diploma or equivalent	20.7	5.8	32.7	34.9	5.8
Associate's degree	15.2	7.2	33.8	37.3	6.6
Bachelor's degree	13.4	4.1	31.7	42.7	8.1
Master's degree or higher	10.8	3.7	27.7	47.2	10.7

[a] Above biology 1 includes chemistry 1, biology 2, Advanced Placement/International Baccalaureate (AP/IB) biology, chemistry 2, AP/IB chemistry, physics 2, and AP/IB physics.
[b] Hispanic may be any race. American Indian or Alaska Native, Asian, black or African American, Native Hawaiian or Other Pacific Islander, white, and more than one race refer to individuals who are not of Hispanic origin.
[c] Other includes Alaska Native, American Indian, Native Hawaiian, Pacific Islander, and more than one race.
[d] The highest level of education achieved by either parent.

NOTE: Detail may not sum to total due to rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of High School Longitudinal Study of 2009 (HSLS:09), National Center for Education Statistics. See appendix table 1-9.

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least one parent with a bachelor's degree (29% versus 13%) (table 1-4). Asian students were twice as likely as other racial and ethnic groups to report enrollment in a science course above biology 1 (14% versus about 7% for all other racial and ethnic groups).

Participation and Performance in the Advanced Placement Program

Several programs offer high school students the opportunity to earn college credit while still in high school. The AP program is one of the largest and best known. Other options for students interested in earning college credit during high school include dual enrollment, with students concurrently enrolling in college courses while still in high school, and the International Baccalaureate program, which offers college credit for high school courses (Thomas et al. 2013).

In the AP program, students take college-level courses at their high school. Courses are offered in 34 different subjects and students who earn a passing score (3 or higher out of 5) on an AP exam can earn college credits, placement into more advanced college courses, or both, depending on the policy of the postsecondary institution they attend. Research suggests that students who take AP or other college-level courses in high school are more likely to enroll and persist in college than their peers who do not take these courses (Klopfenstein and Thomas 2009; Porter and Polikoff 2012). Access to AP courses is an issue, however. The College Board, the nonprofit organization that administers the AP program, notes that availability and variety of AP courses is lower in schools with higher numbers of low-income and traditionally underserved minority students (College Board 2013). Some schools, particularly small schools and schools in low-income and remote areas, may not offer any AP courses for their students (see sidebar, "Access to Advanced Placement Courses in Mathematics and Science").

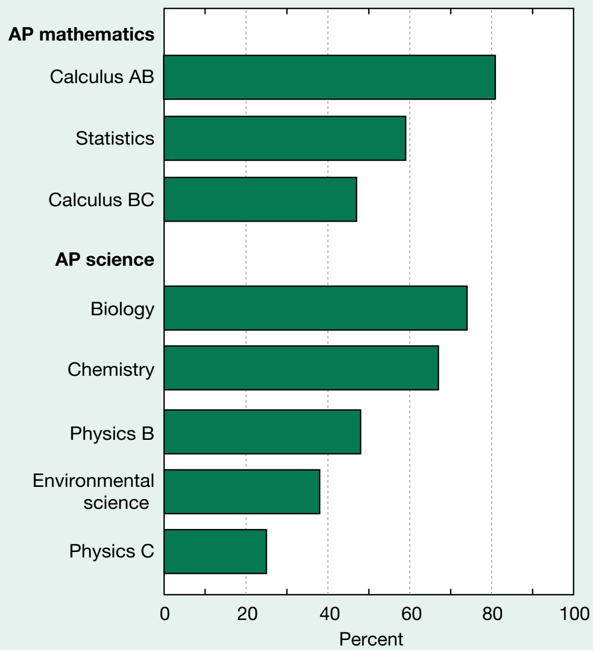
Calculus AB and biology are the most popular AP exams in mathematics and science. According to the College Board, 212,000 students in the graduating class of 2012 took calculus AB and 153,000 students took biology (appendix table 1-10). Statistics and chemistry were the next most popular, with 129,000 students taking the statistics exam and 100,000 taking chemistry. Exam taking is lower for more advanced subjects, including calculus BC (71,000) and physics B (63,000). The least common exams are computer science A (19,000) and physics C: electricity/magnetism (13,000).

The number of students taking at least one AP exam in mathematics or science has doubled in the past decade. In the class of 2012, 500,000 students took an AP mathematics or science exam during high school, up from 250,000

Access to Advanced Placement Courses in Mathematics and Science

The 2012 National Survey of Science and Mathematics Education provides information about school AP course offerings (Banilower et al. 2013). In 2012, AP calculus AB and AP biology were the most widely accessible courses in high schools, available to 81% and 74% of high school students, respectively (figure 1-A).

Figure 1-A
High school students with access to various AP mathematics and science courses: 2012



AP = Advanced Placement.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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The least accessible courses were AP calculus BC in math and AP physics C in science, available to 47% and 25% of high school students, respectively. The number of AP mathematics and science courses offered varied by school characteristics. For example, the largest schools offered an average of two AP mathematics courses and three AP science courses, whereas the smallest schools offered about one AP mathematics and one AP science course (table 1-A). The average number of both mathematics and science courses available at low-poverty schools and suburban and urban schools was about twice those available at high-poverty schools and rural schools.

Table 1-A
Average number of AP mathematics and science courses offered in high schools, by school characteristic: 2012

School characteristic	Mathematics	Science
Students in school eligible for free/reduced-price lunch		
0%–25%	1.4	2.0
25%–50%	1.1	1.5
50%–75%	0.8	1.1
75%–100%	0.7	1.1
School size		
Smallest	0.6	0.7
Second group	0.9	1.2
Third group	1.6	2.1
Largest	2.1	2.8
Community type		
Rural	0.6	0.7
Suburban	1.2	1.7
Urban	1.3	1.7

AP = Advanced Placement.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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students in the class of 2002 (table 1-5). The AP statistics test stands out as experiencing especially rapid growth: In 2002, approximately 40,000 students took the exam, rising to nearly 130,000 students in 2012. Environmental science also experienced rapid growth, rising from 18,000 exam takers in 2002 to 89,000 in 2012.

Although the number of students taking AP exams in mathematics and science has doubled, the AP program in mathematics and science involves a relatively small proportion of all high school students. For example, 17% of all students in the class of 2012 took an AP mathematics or science exam, with 9% passing (table 1-6).

As the number of students taking AP exams has increased, so has the number passing these exams. Nearly 270,000 students in the class of 2012 passed an AP mathematics or science exam in 2012 compared with about 155,000 in 2002 (table 1-5). Although increasing numbers of students are taking and passing AP exams, passing rates have declined or remained steady in most mathematics and science subjects. The overall pass rate for any AP mathematics or science exam dropped from 62% in 2002 to 54% in 2012. The two most popular exams, calculus AB and biology, showed the largest decreases, with average passing rates dropping by 9 percentage points for calculus AB and 13 percentage points for biology since 2002. In contrast, passing rates for exams in more advanced subjects have remained steady or even increased, with average passing rates remaining steady for calculus BC and physics B and increasing by about 7 percentage points for both physics C exams.

Table 1-5
Public school students who took or passed an AP exam in high school, by subject: Graduating classes 2002, 2007, and 2012

Subject	Students who took an AP exam (number)			Students who passed an AP exam (number)[a]			Students who passed an AP exam (%)[a]		
	2002	2007	2012	2002	2007	2012	2002	2007	2012
Any AP exam	471,404	694,705	954,070	305,098	424,004	573,472	64.7	61.0	60.1
Any AP mathematics or science exam	250,465	364,732	497,924	154,450	208,515	268,251	61.7	57.2	53.9
AP mathematics exam									
Calculus AB	123,388	166,239	211,570	81,293	95,338	120,469	65.9	57.3	56.9
Calculus BC	32,760	51,434	70,828	26,078	40,675	57,808	79.6	79.1	81.6
Statistics	40,207	81,992	129,403	22,569	47,578	74,478	56.1	58.0	57.6
AP science exam									
Biology	73,951	109,899	152,742	45,231	64,771	74,211	61.2	58.9	48.6
Chemistry	45,859	72,866	100,362	25,796	40,161	52,689	56.3	55.1	52.5
Environmental science	18,099	41,145	88,683	9,290	20,579	43,350	51.3	50.0	48.9
Computer science A	12,166	11,670	19,067	7,433	6,766	11,743	61.1	58.0	61.6
Physics B	28,688	43,099	63,125	16,514	25,022	36,928	57.6	58.1	58.5
Physics C: Electricity/magnetism	7,141	8,638	12,766	4,586	6,129	9,078	64.2	71.0	71.1
Physics C: Mechanics	14,717	20,672	28,923	10,065	14,570	21,892	68.4	70.5	75.7

AP = Advanced Placement.

[a] Students scoring 3, 4, or 5 on a scale of 1–5 for an AP exam.

NOTES: The College Board reports AP results by graduating class rather than by calendar year. Results include exams taken by graduates throughout their high school career.

SOURCE: The College Board, *The 9th Annual AP® Report to the Nation—Subject Supplement*. Copyright © 2013, www.collegeboard.org. Reproduced with permission.

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Table 1-6
Public school students who took or passed an AP exam as a proportion of overall student population, by subject: Graduating classes 2002, 2007, and 2012
(Percent)

Subject	Students who took an AP exam			Students who passed an AP exam[a]		
	2002	2007	2012	2002	2007	2012
Any subject	18.0	23.5	32.4	11.6	14.3	19.5
Mathematics or science[b]	9.6	12.3	16.9	5.9	7.1	9.1

AP = Advanced Placement.

[a] Students scoring 3, 4, or 5 on a scale of 1–5 for an AP exam.
[b] Includes calculus AB, calculus BC, statistics, biology, chemistry, environmental science, computer science A, physics B, physics C: electricity/magnetism, and physics C: mechanics.

NOTES: The College Board reports AP results by graduating class, rather than by calendar year. Results include exams taken by graduates throughout their high school career.

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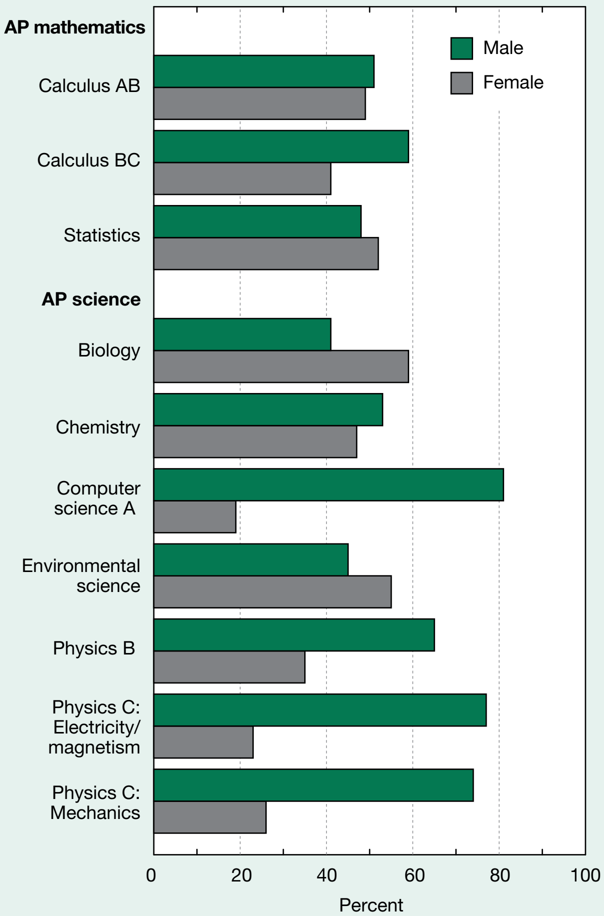
AP exams covering more advanced material, such as calculus BC and physics, are taken by fewer students, but the pass rates are much higher. For example, 70,000 students in the class of 2012 took the calculus BC exam; more than 200,000 took the relatively less demanding calculus AB exam. The pass rate for calculus BC was 82%, compared with 57% for calculus AB (table 1-5). In science, about 13,000 students in the class of 2012 took the physics C: electricity/magnetism exam; more than 150,000 students took the AP biology exam. The pass rate for physics C was 71%, much higher than the passing rate for AP biology (49%).

AP Exam Taking by Sex and Race and Ethnicity

The proportion of male and female students taking particular AP exams differs by test subject (figure 1-12). Male students are more likely than female students to take AP exams in advanced subjects, including calculus BC (59% versus 41%), physics B (65% versus 35%), and both physics C

Figure 1-12
Public school students in graduating class of 2012 who took AP exams in mathematics and science in high school, by sex



AP = Advanced Placement.

NOTES: The College Board reports AP results by graduating class rather than by calendar year. Results include exams taken by graduates throughout their high school career.

SOURCE: The College Board, *The 9th Annual AP® Report to the Nation—Subject Supplement*. Copyright © 2013, www.collegeboard.org. Reproduced with permission.

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exams (about 75% versus 25%). Similar percentages of male and female students took AP exams in calculus AB and statistics. Female students took AP exams at higher rates than male students in biology (59% versus 41%) and environmental science (55% versus 45%). Computer science A showed the largest difference in exam taking by sex, with a distribution of 81% of male students and 19% of female students.

Black and Hispanic students are underrepresented among AP exam takers. Although black students made up about 15% of the 2012 graduating class, they comprised less than 8% of students taking any AP mathematics or science exam (appendix table 1-10). Black students were particularly underrepresented in the exam-taking population for AP exams in calculus BC and both physics C exams, accounting for only about 3% of the students taking those exams. Hispanic students, who made up about 18% of the class of 2012, were also underrepresented in the AP exam-taking population. Their representation among AP exam takers ranged from a high of 15% for environmental science to a low of 8% for calculus BC and 7% for physics C: electricity/magnetism. Conversely, Asian students are overrepresented among AP exam takers. Asian students accounted for about 6% of the class of 2012 but accounted for about 30% of the exam takers in physics C: electricity/magnetism, calculus BC, and computer science A. Their lowest representation among exam takers was 13% for environmental science.

Teachers of Mathematics and Science

Teacher quality is one of the most important factors influencing student learning. Students' achievement in mathematics and science depends in part on their access to high-quality instruction in those subjects. Many factors affect teacher quality, including qualifications, ongoing professional development, attrition, and working conditions. The 2012 National Survey of Science and Mathematics Education (NSSME), the fifth in a series of surveys of mathematics and science teachers first administered in 1977, provides a comprehensive review of these topics (Banilower et al. 2013). The 2012 NSSME is a nationally representative survey based on a sample of 7,752 mathematics and science teachers in elementary and secondary schools across the United States. This section highlights the major findings of the NSSME and supplements those findings with national data on teacher attrition from the U.S. Department of Education's Beginning Teacher Longitudinal Study (BTLS).[31]

Characteristics of High-Quality Teachers

Extensive research suggests that high-quality teaching has a positive effect on student achievement (Boyd et al. 2008; Clotfelter, Ladd, and Vigdor 2007; Goe 2008; Guarino, Santibanez, and Daley 2006; Hanushek 2011; Harris and Sass 2011), but the specific teacher characteristics that contribute to student success are less clear. 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 their teaching effectiveness (Boyd et al. 2006; Buddin and Zamarro 2009a, 2009b; Hanushek and Rivkin 2006; Harris and Sass 2011; Sass et al. 2012). Efforts to improve measures of teaching quality have proliferated in recent years. Recent efforts have focused on "value-added" models—strategies for measuring teacher effectiveness by comparing test score gains of students in the same school who have similar backgrounds and initial scores but different teachers (Baker et al. 2010; Goldhaber, Liddle, and Theobald 2013; Hanushek and Rivkin 2006; Harris and Sass 2011; Loeb, Kalogrides, and Béteille 2012). Following this line of research, some researchers, including the Measures of Effective Teaching (MET) Project and the

National Center for Teacher Effectiveness (NCTE), have attempted to establish composite indicators for effective teaching (Kane et al. 2013; MET Project 2012; NCTE 2013).

This section reports on several indicators of teacher quality that are available from major national studies, including teaching experience, professional certification, in-field preparation (i.e., earning a postsecondary degree in the teaching field), content coursetaking, and teachers' self-assessment of their preparation. Other less easily observed characteristics may also contribute to teacher effectiveness, including teachers' abilities to motivate students, engage students in learning, maximize instruction time, and diagnose and overcome students' learning difficulties. However, these characteristics are often difficult and costly to measure and therefore are rarely included in nationally representative surveys.

Teaching Experience. In general, as teachers gain more years of experience, they become more effective in helping students learn (Boyd et al. 2006; Harris and Sass 2011; Clotfelter, Ladd, and Vigdor 2007; Rice 2010). Recent studies have found that novice teachers (i.e., teachers with 2 or fewer years of experience) are more likely than experienced teachers to work in high-poverty, high-minority schools and teach low-achieving students (Loeb, Kalogrides, and Béteille 2012; LoGerfo, Christopher, and Flanagan 2012; Sass et al. 2012). According to data from the NSSME, in 2012, the percentage of novice mathematics teachers ranged from 10% to 14% in elementary, middle, and high schools, whereas the percentage of novice science teachers ranged from 13% to 16% across the school levels (figure 1-13).

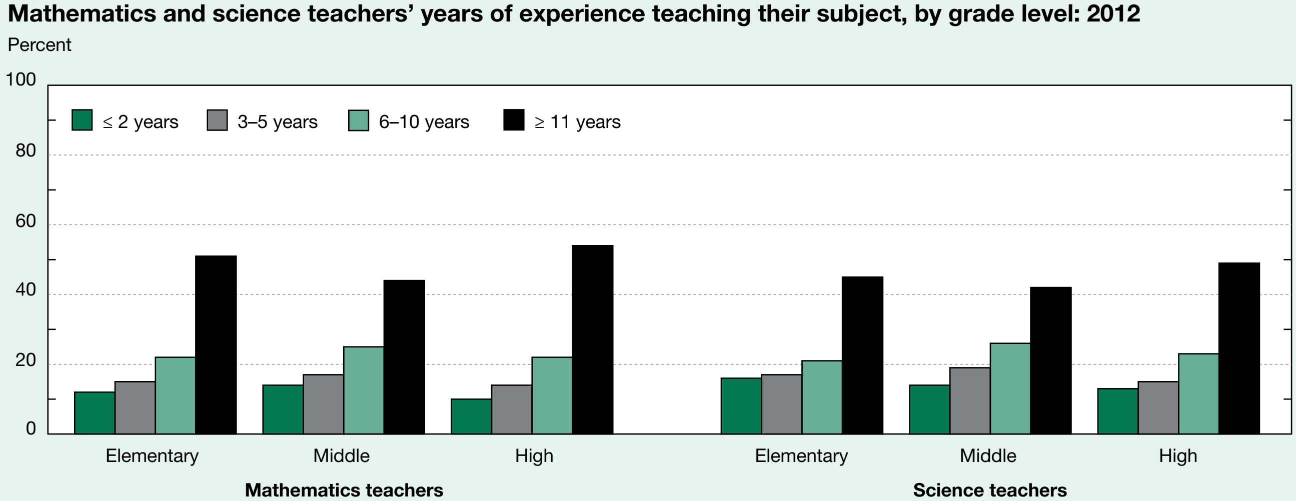
Schools with the highest proportions of low-income students were more likely than other schools to have novice science teachers. In schools with the highest concentrations of students eligible for free/reduced-price lunch (FRL) (i.e., 75%–100% of students), 23% of science classes were taught by teachers with 2 or fewer years of experience, compared with 10% of science classes in schools with the lowest concentrations of FRL-eligible students (i.e., 0%–25% of students) (figure 1-14). In contrast, the distribution of novice mathematics teachers did not vary significantly depending on a school's percentage of FRL students. Moreover, students in high-poverty schools were much less likely to have novice teachers in mathematics than in science: 14% of mathematics classes, compared with 23% of science classes, were taught by teachers with 2 or fewer years of experience.

A similar pattern was seen across mathematics and science for non-Asian minority students. Science classes with the highest percentages of non-Asian minority students were more likely to have novice science teachers (21%) than were classes with the lowest percentages of non-Asian minority students (14%), but such differences were not observed for mathematics teachers (appendix table 1-11).

Higher-achieving students tended to have more experienced mathematics teachers. For example, 15% of math classes composed of mostly low achievers had mathematics teachers with 2 or fewer years of experience, whereas 8% of math classes composed of mostly high achievers had such mathematics teachers (appendix table 1-11). A similar pattern appears for science, with classes of mostly low achievers (18%) more likely than classes of mostly high achievers (12%) to have science teachers with 2 or fewer years of experience.

Certification. Each state requires public school teachers to earn a certificate that licenses them to teach. States set criteria for various types of certification; usually a full certification entails a combination of passing scores on tests, a

Figure 1-13
Mathematics and science teachers' years of experience teaching their subject, by grade level: 2012



NOTE: Detail may not sum to total due to rounding.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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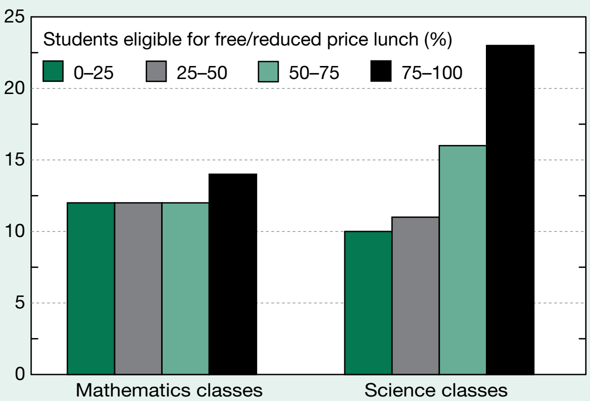
bachelor's degree with a specified number of credits in education and in the discipline taught, and supervised practice teaching experience (NCTQ 2013). Criteria for certification vary among grade levels, with elementary teachers usually certified to teach multiple subjects and high school teachers certified within subject areas. Whether middle school teachers are certified in multiple subjects or individual subjects varies across states.

Fully certified teachers are distinguished from those who are granted alternative certificates. Alternative certificates are issued to persons who must complete a certification program in order to continue teaching, those who have satisfied all requirements except the completion of a probationary teaching period, and those who require some additional coursework or need to pass a test.

Figure 1-14
Mathematics and science classes taught by teachers with 2 years or less of experience teaching their subject, by students in school eligible for free/reduced-price lunch: 2012
Percent



SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013). See appendix table 1-11.

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The NSSME reported four different paths to full and alternative certification: an undergraduate program leading to a bachelor's degree and teaching certificate; a post-baccalaureate program leading to a certificate; a master's program that also awarded a teaching certificate; and no formal teacher preparation. Elementary mathematics and science teachers were the most likely to have earned a bachelor's degree and teaching certificate as part of an undergraduate program: about 60% of elementary teachers of mathematics and science followed this path to certification, compared with 48% of high school mathematics teachers and 34% of high school science teachers (table 1-7). In contrast, high school mathematics and science teachers were more likely than their elementary counterparts to have earned a certificate through a post-baccalaureate program—30% of high school science teachers followed this path to certification, compared with 13% of elementary school science teachers. High school mathematics and science teachers were also more likely to report no formal teacher preparation (8% and 10%, respectively) than were their elementary school counterparts (1%).

Some studies have shown that fully certified mathematics and science teachers are more prevalent in low-poverty and low-minority schools (NSB 2012). Students from disadvantaged backgrounds (minority students, low-SES students, and those whose first language was not English) are more likely than their counterparts to be taught by mathematics or science teachers with alternative certification (LoGerfo, Christopher, and Flanagan 2012). The NSSME did not report data on this issue.

Degree in Field and Content Coursetaking. Over the past decade, few issues related to teaching quality have received more attention than in-field teaching in middle and high schools (Almy and Theokas 2010; Dee and Cohodes 2008; Peske and Haycock 2006). In-field teaching refers to

Table 1-7
Mathematics and science teachers, by path to certification and grade level: 2012
(Percent distribution)

Grade level	An undergraduate program leading to a bachelor's degree and a teaching credential	A post-baccalaureate credentialing program (no master's degree awarded)	A master's program that also awarded a teaching credential	No formal teacher preparation
Mathematics teachers				
Elementary	63	14	22	1
Middle	55	17	25	3
High	48	20	22	10
Science teachers				
Elementary	61	13	25	1
Middle	47	23	26	4
High	34	30	28	8

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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the assignment of teachers to teach subjects that match their training or education. To some extent, this emphasis can be traced back to the implementation of the federal No Child Left Behind Act (NCLB), which mandated that all students have teachers who demonstrate subject area competence. To determine whether teachers have subject-specific preparation for the fields they teach, recent research has focused on matching teachers' formal preparation (as indicated by degree major, certification field, or both) with their teaching field (Hill and Gruber 2011; McGrath, Holt, and Seastrom 2005; Morton et al. 2008). The NSSME followed a similar approach, using teachers' degree field and postsecondary coursework completed in mathematics and science as indicators of preparation to teach mathematics and science at the elementary, middle, and high school levels (Banilower et al. 2013).[32]

In 2012, 82% of high school science teachers and 73% of high school mathematics teachers held degrees in their teaching field or in science or mathematics education (table 1-8). High school mathematics and science teachers were twice as likely as their middle school counterparts to hold in-field degrees. Very few elementary school teachers who taught mathematics or science held an in-field degree (about 5%).

Many secondary science classes, especially at the high school level, focus on more discrete areas of science, such as biology or chemistry. In 2012, biology teachers were the most likely among high school science teachers to have a degree in their specific teaching field, with 53% having a degree in biology (appendix table 1-12). Another 37% had at least three college courses beyond introductory biology. In mathematics, 52% of high school mathematics teachers had a degree in mathematics (table 1-8). Almost all high school mathematics teachers had completed a calculus course (93%), and the vast majority of them had taken college coursework in advanced calculus (79%), linear algebra (80%), and statistics (83%) (appendix table 1-13). Other college courses completed by the majority of high school mathematics teachers included abstract algebra (67%), differential equations (62%), axiomatic geometry (55%), analytic geometry (53%), probability (56%), number theory (54%), and discrete mathematics (52%). About 77% of high school mathematics teachers had taken a course in computer science. Substantially fewer middle school teachers had taken college coursework in each of these subject areas.

According to the NSSME data, the likelihood of middle and high school classes being taught by a teacher with in-field preparation varied by the concentration of high or low achievers in both mathematics and science classes and by the percent of non-Asian minority students in mathematics classes. For example, 61% of mathematics classes and 76% of science classes composed mostly of high-achieving students were taught by teachers with an in-field degree, compared with 49% of mathematics classes and 50% of science classes composed mostly of low-achieving students (appendix table 1-14). The difference by the concentration of non-Asian minority students was large for mathematics but less so for science: 44% of classes with the highest percentage of non-Asian minority students had a mathematics teacher with an in-field degree, compared with 64% of classes with the lowest percentage of such students; for science, it was 58% and 68%, respectively. The differences among schools with the highest and lowest percentages of FRL-eligible students ranged from 58% to 68% (statistically significant) for science and from 51% to 56% (not statistically significant) for math.

Although elementary school teachers are not generally expected to have degrees in mathematics or science, both the National Council of Teachers of Mathematics (NCTM) and the National Science Teachers Association (NSTA) have recommendations for the number and types of courses that elementary teachers should take to be adequately prepared to teach these subjects (Banilower et al. 2013). The NSTA suggests that elementary science teachers have one course each in life, earth, and physical sciences. In 2012, 36% of elementary school teachers met this standard, and 38% had taken courses in two of the three areas (figure 1-15). Six percent of elementary teachers had no college courses in science. For mathematics, the NCTM recommends that elementary school teachers take college coursework in five areas, including numbers and operations, algebra, geometry,

Table 1-8
Mathematics and science teachers with an undergraduate or graduate degree in mathematics or science, by grade level: 2012
(Percent)

	Mathematics teachers' degree				Science teachers' degree			
Grade level	Mathematics	Mathematics education	Mathematics or mathematics education	None of these fields	Science or engineering	Science education	Science, engineering, or science education	None of these fields
Elementary	4	2	4	96	4	2	5	95
Middle	23	26	35	65	26	27	41	59
High	52	54	73	27	61	48	82	18

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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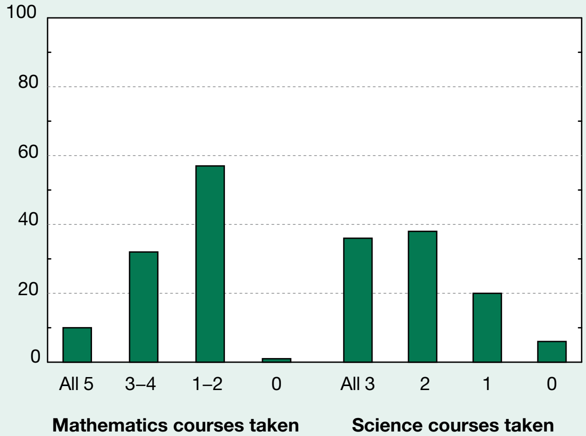
Figure 1-15
Elementary teachers meeting NCTM- and NSTA-recommended college-level coursework in mathematics and science: 2012



NCTM = National Council of Teachers of Mathematics; NSTA = National Science Teachers Association.

NOTES: NCTM recommended that elementary teachers take college-level courses in number and operations, algebra, geometry, probability, and statistics. NSTA recommended that elementary teachers take college-level courses in life science, earth science, and physical science. Detail may not sum to total due to rounding.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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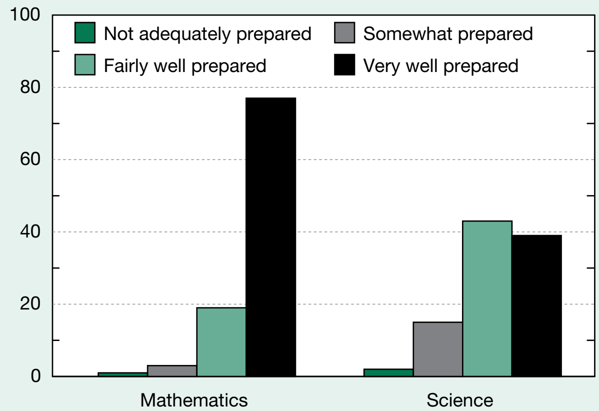
Figure 1-16
Elementary teachers' self-assessment of their preparedness to teach mathematics and science: 2012



NOTE: Detail may not sum to total due to rounding.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013). See appendix table 1-15.

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probability, and statistics. In 2012, 10% of elementary teachers met the standard of having coursework in all five of these areas, 57% had courses in one to two of these areas, and 1% had no courses in these areas.

Self-Assessment of Preparedness to Teach. Elementary teachers were much more confident in their ability to teach mathematics than in their ability to teach science: 77% of elementary teachers felt very well prepared to teach mathematics, but just 39% reported being very well prepared to teach science (figure 1-16). Within mathematics, elementary teachers felt most prepared to teach numbers and operations; three-quarters reported that they felt very well prepared to teach this topic, compared with approximately half who felt very well prepared to teach measurement, geometry, and early algebra (appendix table 1-15). Within science, elementary teachers felt most prepared to teach life and earth science, with about one-fourth reporting feeling very well prepared to teach these topics. In contrast, just 17% reported feeling very well prepared to teach physical science, and 4% reported feeling very well prepared to teach engineering.

Middle and high school teachers of mathematics and science who were surveyed in the NSSME were asked about their perceived level of preparedness to teach subtopics within their major subject areas. High school chemistry teachers were the most likely to report feeling very well prepared to teach topics in their discipline, ranging from 66% for properties of solutions to 83% for elements, compounds, and mixtures (appendix table 1-16). Overall, high school science teachers felt more prepared to teach biology, chemistry, and physics than middle school science teachers, but no difference was found in levels of preparedness between grade levels for teaching earth or environmental science. Both middle and high school science teachers reported very little preparedness for teaching engineering, with 6% of middle school and 7% of high school teachers reporting they felt very well prepared.

In mathematics, high school teachers were generally more likely than middle school teachers to report feeling very well prepared to teach most topics. For example, 91% of high school teachers reported feeling very well prepared to teach algebraic thinking, compared with 76% of middle school teachers (appendix table 1-17).

Self-Assessment of Preparedness for Tasks Associated with Instruction. In the NSSME, mathematics and science teachers were also asked how well prepared they felt to manage tasks associated with instruction, including handling classroom discipline and encouraging underrepresented groups to participate in their subject. The majority of respondents felt very well prepared to handle classroom discipline, with elementary school teachers most likely to feel prepared (about 70% compared with about 60% of middle and high school teachers) (table 1-9). About half of mathematics and science teachers at most levels felt very well prepared to encourage the participation of female students in mathematics and science. Elementary teachers of science were an exception—only 30% felt well prepared to encourage female participation

Table 1-9
Mathematics and science teachers considering themselves very well prepared for various tasks associated with instruction, by grade level: 2012
(Percent)

Grade level	Manage classroom discipline	Encourage students' interest in mathematics or science	Encourage participation of females in mathematics or science	Encourage participation of low-SES students in mathematics or science	Encourage participation of racial or ethnic minorities in mathematics or science
Mathematics teachers					
Elementary	69	48	56	52	50
Middle	61	46	56	53	48
High	58	39	51	40	39
Science teachers					
Elementary	72	25	30	31	30
Middle	60	39	46	36	36
High	59	53	55	44	44

SES = socioeconomic status.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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in science. In mathematics, about half of elementary teachers felt very well prepared to encourage students from low-SES groups and racial or ethnic minorities to participate in their subject, compared with about 40% of high school mathematics teachers. This pattern was reversed among science teachers, with high school teachers more likely to feel very well prepared to encourage participation among students from these groups (about 45% at the high school level compared with about 30% at the elementary level). Teachers of science at the elementary level felt the least prepared overall to encourage interest in science among all students, with just 25% reporting feeling well prepared to do so.

Teacher Professional Development

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 teacher professional development can have measurable effects on student performance. For example, an analysis examining outcomes across 16 studies of professional development for mathematics and science teachers found that professional development had significant effects on student performance in mathematics (CCSSO 2009). The 2012 NSSME collected data on how recently mathematics and science teachers participated in subject-specific professional development and how many hours they spent on professional development in the past 3 years.

Recent Participation. A majority of middle school and high school mathematics and science teachers participated in at least one professional development activity focused on mathematics or science in the last 3 years. The rates for middle and high school science teachers ranged from 82% to 89% (table 1-10). Teachers responsible for elementary science instruction were far less likely to participate in a science-focused professional development activity, with 59% reporting participation in at least one such activity in the past 3 years and 15% reporting that they had never participated in a science-focused professional development activity (compared with 3%–6% of teachers at all other levels and subjects).

Time Spent. In the NSSME, teachers were asked to report the number of hours that they had spent on subject-specific professional development in the past 3 years. About 36% of high school science teachers and 32% of high school mathematics teachers reported that they had spent more than 35 hours participating in subject-specific professional development activities in the past 3 years (table 1-11). Elementary science teachers were the least likely to have spent time participating in subject-specific professional development: 65% reported participation in less than 6 hours of professional development, compared with 35% of elementary mathematics teachers and 22%–30% of middle school and high school mathematics and science teachers.

Teachers' Working Conditions

Teachers' perceptions of their working conditions play a role in determining the supply of qualified teachers and influencing their decisions about remaining in the profession (Darling-Hammond and Sykes 2003; Hanushek, Kain, and Rivkin 2004; Ingersoll and May 2012; Ladd 2009; Johnson et al. 2004). Mathematics and science teachers are more likely than other teachers to cite job dissatisfaction as a reason for leaving teaching (Ingersoll and May 2012). Safe

Table 1-10
Mathematics and science teachers, by most recent participation in subject-focused professional development and grade level: 2012
(Percent distribution)

Grade level	In the past 3 years	4–6 years ago	7–10 years ago	More than 10 years ago	Never
Mathematics teachers					
Elementary	87	7	1	1	3
Middle	89	4	1	2	4
High	88	6	2	1	4
Science teachers					
Elementary	59	16	5	5	15
Middle	82	6	3	4	6
High	85	7	2	1	5

NOTE: Detail may not sum to total due to rounding.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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environments, strong administrative leadership, cooperation among teachers, high levels of parent involvement, and sufficient learning resources can enhance teachers' commitment to their schools, promote job satisfaction, and improve teachers' effectiveness (Berry, Smylie, and Fuller 2008; Brill and McCartney 2008; Guarino, Santibanez, and Daley 2006; Ingersoll and May 2012). Among the working conditions that contribute to teachers' dissatisfaction are lack of administrative support, low parent involvement, and student discipline problems (Ingersoll and May 2012; Guarino, Santibanez, and Daley 2006). Moreover, teacher job satisfaction and retention rates tend to be lower in schools with high proportions of minority, low-income, or low-achieving students (Berry, Smylie, and Fuller 2008; Hanushek, Kain, and Rivkin 2004; Ingersoll and May 2012).

The NSSME provides extensive data on working conditions that affect teachers' perceptions of their school environments. Mathematics and science program representatives at each school site were asked to identify which school factors inhibited or promoted effective instruction in their subject area. Mathematics program representatives were more likely to report that their schools were supportive of math instruction than science program representatives were to report that their schools were supportive of science instruction. For example, 82% of mathematics program representatives reported that the importance their school placed on subject teaching promoted effective instruction in mathematics, whereas 60% of science program representatives reported so for instruction in science (appendix table 1-18). About 70% of mathematics program representatives and 53% of science program representatives agreed that school management of instructional resources promoted effective instruction in their subject. Many of the representatives (52%–65%) also agreed that district professional development policies and practices promoted effective teaching in their subject area. Relatively lower percentages of respondents (56% for mathematics and 44% for science) agreed that the time provided

Table 1-11
Mathematics and science teachers spending time in subject-focused professional development in the past 3 years, by grade level: 2012
(Percent distribution)

Grade level	< 6 hours	6–15 hours	16–35 hours	> 35 hours
Mathematics teachers				
Elementary	35	35	20	11
Middle	22	24	23	31
High	23	24	22	32
Science teachers				
Elementary	65	22	8	4
Middle	30	24	20	27
High	23	20	21	36

NOTE: Detail may not sum to total due to rounding.

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, Report of the 2012 National Survey of Science and Mathematics Education (2013).

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for teacher professional development promoted effective instruction in their subject area.

School program representatives were also asked to rate the extent to which several factors were problems for instruction. These included student factors such as high absenteeism, lack of student interest, low reading ability, and inappropriate behavior; teacher factors such as lack of teacher interest and insufficient time to share ideas; and school factors such as inadequate funds for equipment. Representatives were asked to classify issues on a scale, ranging from "not a significant problem" to "a serious problem."

For science instruction, one of the most frequently cited problems was inadequate funds for purchasing equipment: about 30% of program representatives in elementary, middle, and high schools reported this as a serious problem for science instruction (table 1-12). At the middle and high

Table 1-12
School program representatives reporting various issues as serious problems for mathematics and science instruction, by school level: 2012
(Percent)

Issues	Mathematics instruction			Science instruction		
	Elementary	Middle	High	Elementary	Middle	High
Student issues						
High student absenteeism	8	13	16	8	13	13
Inappropriate student behavior	10	16	10	9	15	8
Low student interest in mathematics or science	14	25	30	5	11	13
Low student reading abilities	22	24	20	16	19	19
Teacher issues						
Insufficient time to teach mathematics or science	13	12	10	27	17	10
Lack of opportunities for teachers to share ideas	15	14	9	20	16	13
Lack of teacher interest in mathematics or science	2	1	2	4	3	2
School issues						
Inadequate funds for purchasing equipment and supplies	12	18	16	30	32	28
Lack of parental support	15	17	15	10	14	9

SOURCE: Banilower ER, Smith PS, Weiss IR, Malzahn KA, Campbell KM, Weis AM, *Report of the 2012 National Survey of Science and Mathematics Education* (2013).

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school levels, 19% of respondents cited low student reading abilities as a serious problem for science instruction in their schools; 16% of elementary program respondents cited low reading ability as a serious problem. Several other problems were reported more frequently in elementary schools than in high schools, including insufficient time to teach science (27% versus 10%) and lack of opportunities for science teachers to share ideas (20% versus 13%). Low student interest in science was cited as a serious problem for instruction among 5% of respondents in elementary schools and 13% of those in high schools. For mathematics instruction at the elementary level, the most frequently cited problem was low student reading abilities (22%), which was mentioned substantially more often than low student interest in mathematics (14%). At the high school level, this pattern was reversed: 30% of respondents mentioned low student interest in math as a serious problem but only 20% mentioned low student reading ability. At the middle school level, percentages of respondents mentioning these two problems were similar (about 25%).

In the NSSME data, both mathematics and science teachers in high-poverty schools found student behavior problems to be a greater barrier to effective instruction than did teachers in low-poverty schools (Banilower et al. 2013). Teacher behavior was also more frequently seen as a problem in high-poverty schools compared with low-poverty schools, though to a far lesser extent than student behavior.

Mathematics and Science Teacher Attrition

In view of the potential for large numbers of teachers to retire in the next few years and the importance of improving students' mathematics and science achievement, both government (The White House 2012) and advocacy organizations (see sidebar "100Kin10") seek to prepare more new mathematics and science teachers to ensure that there is an ample supply of highly qualified teachers in these subjects. If, however, new teachers leave the profession within a few years of beginning teaching, attrition may negate efforts to expand the teaching force (Ingersoll and Perda 2010). A recent study found that teacher attrition varied greatly among schools, and that high-poverty, high-minority, and urban public schools had the highest mathematics and science teacher turnover (Ingersoll and May 2012).

Annual attrition rates among public school teachers, measured by the Teacher Follow-up Survey six times since 1988–89, indicate that mathematics and science teachers leave the profession at about the same rates as all teachers do (NSB 2012). Eight percent of all 2007 teachers had left the profession by 2008, and the corresponding rates for mathematics and science teachers were similar (8% and 9%, respectively) (NSB 2012).

The Beginning Teacher Longitudinal Study (BTLS) expands the ability to measure teacher attrition from 1-year rates to cumulative rates for each of the first 5 years of teaching. It focuses specifically on the attrition rate of beginning teachers rather than yearly attrition rates for all teachers. Beginning teachers who entered the profession in 2007–08 were surveyed in their first year and again in each of the next

100Kin10

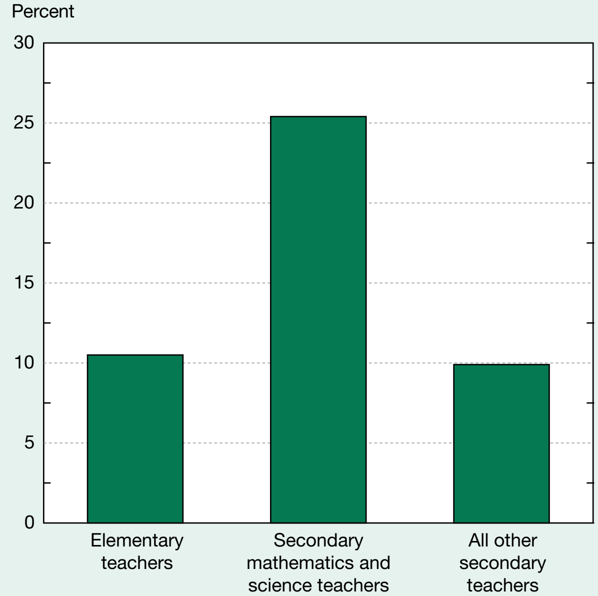
100Kin10 aims to ensure that all U.S. students have the STEM literacy needed to prepare them for employment and citizenship. In 2011, President Obama set a goal of training 100,000 well-qualified mathematics and science educators over the next 10 years. 100Kin10 was launched to meet this goal by improving STEM teacher training and retention. Begun through the efforts of the Carnegie Corporation of New York and Opportunity Equation, the program brings funders together with partners from a variety of sectors (e.g., federal and state government agencies, corporations, universities, and nonprofits) to contribute toward the overall goal. 100Kin10 aims to build long-term capacity for training and retaining STEM teachers by evaluating the implementation of programs and identifying and disseminating best practices. The University of Chicago (Urban Education Institute and Center for Elementary Mathematics and Science Education) is developing methods and tools that will allow partners to view emerging data, measure the impact of their investments, and create opportunities for partners to work with and learn from each other.

As of August 2013, 26 funders have pledged more than $52 million toward the work of 100Kin10 partner organizations. More than 150 partner organizations have been selected to participate and have currently committed to training 40,000 STEM teachers by 2016. More information about 100Kin10 and current partners can be found at http://www.100kin10.org/.

4 years to gather information on their early careers. This section reviews data from the first 3 years of the study.

Although rates of attrition after the first year of teaching in the BTLS were not significantly different among mathematics and science teachers and teachers of other subjects at the secondary level, the situation changed by the third year of teaching. At the secondary level, beginning mathematics and science teachers' rates of attrition by their third year of teaching were higher than the rates of those who taught other subjects. Whereas 10% of other secondary-level teachers had left the profession by 2009−10 (their third year of teaching), 25% of secondary mathematics and science teachers had departed by then (figure 1-17; appendix table 1-19). Beginning secondary mathematics and science teachers' attrition rates as of the third year also exceeded those of beginning elementary teachers (11%). Although statistically significant, these results are based on a small sample of teachers and should be interpreted with caution. Data from years 4 and 5 of the study will enable more conclusive findings about the attrition rates of secondary mathematics and science teachers compared with secondary teachers of other subjects.

Figure 1-17
Beginning public elementary and secondary teachers (2007–08) who had left teaching by 2009–10



SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of Beginning Teacher Longitudinal Study (BTLS), First Through Third Wave Preliminary Data File, 2007–08, 2008–09, 2009–10, National Center for Education Statistics. See appendix table 1-19.

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Instructional Technology and Digital Learning

Federal and state policies encourage greater use of instructional technology, increasingly referred to as "digital learning" or "digital education." The Alliance for Excellent Education defines digital learning as "any instructional practice that is effectively using technology to strengthen the student learning experience" (Alliance for Excellent Education 2012). Digital learning encompasses a broad array of tools and practices, including online courses, applications of technology in the classroom, computer-based assessment, and adaptive software for students with special needs. In 2010, the U.S. Department of Education released a National Education Technology Plan (NETP) calling for the use of advanced technologies throughout the education system to improve student learning, accelerate implementation of effective practices, and enable schools to use data and information for continuous improvement (U.S. Department of Education 2010). Since publication of the NETP, reports about and initiatives involving digital education have proliferated (Alliance for Excellent Education 2011, 2012; Staker and Horn 2012; Watson et al. 2012; Wicks 2010).

The National Council of Teachers of Mathematics, for example, strongly endorsed the use of educational technology in mathematics education, saying that it is "essential" and "enhances student learning" (National Council of Teachers of Mathematics 2011). Findings from a number of studies have shown that the strategic use of technology tools in mathematics and science education, in particular, can support the learning of mathematical and scientific procedures and skills as well as the development of advanced proficiencies such as problem solving and reasoning (Hegedus and Roschelle 2013; Pierce et al. 2011; Rutten, van Joolingen, and van der Veen 2012). Proponents suggest that computer applications and technological tools, either alone or in concert with traditional instruction, may improve student achievement in mathematics and science by tailoring lessons and skill practice to individual students' needs or by offering students additional opportunities to interact with information through computer simulations or other methods. In addition, computerized assessment may provide more precise and efficient feedback on student learning, allowing teachers to adapt instruction to student needs more effectively (Tucker 2009). Instruction through technology may also motivate students' interest in mathematics and science.

This section focuses specifically on instructional technology, defined as technology products and tools designed to assist teaching and learning, in elementary and secondary schools. It distinguishes between the use of technology as an instructional tool and online learning, a special form of distance education. The section begins by discussing recent research on the effectiveness of technology as an instructional tool. It then updates national estimates of access to computers and the Internet and examines the current state of distance education, specifically online learning. This section ends with an overview of the research on the effectiveness of online learning.

Technology as an Instructional Tool

The use of instructional technology in K−12 classrooms has been growing at a rapid pace. Many school districts have invested in technology such as computers, mobile devices, and interactive whiteboards. In 2009, NCES surveyed a nationally representative sample of teachers to determine the availability and use of educational technology among teachers in public elementary and secondary schools. Teachers reported having the following technology devices either available as needed or in the classroom every day: LCD (liquid crystal display) or DLP (digital light processing) projectors (36% available as needed and 48% in the classroom every day), interactive whiteboards (28% and 23%, respectively), and digital cameras (64% and 14%, respectively) (table 1-13). Among teachers who reported that these devices were available to them, one-half or more also reported that they used these devices for instruction sometimes or often: 72% of teachers used LCD or DLP projectors, 57% used interactive whiteboards, and 49% used digital cameras (Gray, Thomas, and Lewis 2010).

The 2012 NSSME surveyed teachers about the adequacy of the instructional technology (e.g., computers, calculators, probes/sensors) available to them (Banilower et al. 2013). High school mathematics teachers were the most likely to indicate that their instructional technology resources were adequate (69%), whereas elementary and middle school science teachers were the least likely to indicate so (35%) (Banilower et al. 2013).

Research on Instructional Technology

Despite the rapid growth in the use of technology in classrooms, a substantial base of rigorous research on the effectiveness of technology in improving student achievement is lacking. Few national studies are available and many

Table 1-13
Public school teachers reporting the availability and frequency of use of technology devices, by school level: 2009
(Percent)

School level	Digital projector			Interactive whiteboard			Digital camera		
	Availability		Used for instruction sometimes or often[a]	Availability		Used for instruction sometimes or often[a]	Availability		Used for instruction sometimes or often[a]
	As needed	In classroom every day		As needed	In classroom every day		As needed	In classroom every day	
All public school teachers[b]	36	48	72	28	23	57	64	14	49
Elementary	37	44	68	31	23	58	67	14	53
Secondary	33	56	78	23	23	58	57	13	41

[a] Based only on teachers reporting that the device was available as needed or in the classroom every day.
[b] Data for teachers in combined schools (i.e., those with both elementary and secondary grades) are included in All public school teachers but are not shown separately.

SOURCE: Gray L, Thomas N, Lewis L., *Teachers' Use of Educational Technology in U.S. Public Schools: 2009*, NCES 2010-040 (2010).

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studies that have been conducted are often of brief duration and are product-specific studies based on small samples and nonrigorous research designs. The Office of Educational Technology has issued a report outlining the problems with current research into digital education and providing a framework for how research evidence can be improved (U.S. Department of Education 2013).

Three recent meta-analyses reviewed studies that compared the mathematics achievement of students taught in elementary and secondary classes using technology-assisted mathematics programs with that of students in control classes using alternative programs or standard methods (Cheung and Slavin 2011; Li and Ma 2010; Rakes et al. 2010). All three studies found small positive effects on student achievement when technology was incorporated into classroom mathematics instruction.[33]

One recent study used a randomized control trial design to examine the effectiveness of a technology-based algebra curriculum in a wide variety of middle schools and high schools in seven states (Pane et al. 2013). Participating schools were matched into similar pairs and randomly assigned to either continue with the current algebra curriculum for 2 years or to adopt a technology-assisted program using a personalized, mastery-learning, blended-learning approach. Schools assigned to implement the program did so under conditions similar to schools that independently adopted it. Analysis of posttest outcomes on an algebra proficiency exam found no effects in the first year of implementation but found strong evidence in support of a positive effect in the second year. The estimated effect was statistically significant for high schools but not for middle schools; in both cases, the magnitude was sufficient to improve the average student's performance by approximately 8 percentage points.

An earlier national study of the effectiveness of instructional technology failed to find any statistically significant effects of several specific instructional technologies on student achievement (Dynarski et al. 2007). Researchers tested three grade 6 math products in 28 schools and three algebra products in 23 schools. Teachers in selected schools volunteered to participate and were randomly assigned to use or not use the educational software. Researchers compared students' test results and other outcomes. No effects on sixth grade mathematics or algebra achievement were observed. During the second year of the evaluation, two grade 6 math products and two algebra products were tested, and again researchers observed no significant effects on student achievement (Campuzano et al. 2009). No science products were tested.

Several small-scale studies of specific instructional technology applications suggest that educational computer programs and video games may promote student engagement and learning when they make use of proven pedagogical techniques (Barab et al. 2007; Ketelhut 2007; Nelson 2007; Neulight et al. 2007; Steinkuehler and Duncan 2008). One study found that the use of interactive whiteboard technology was associated with increased motivation in mathematics among elementary school students (Torff and Tirotta 2010). Another study of a popular algebra program found that students randomly assigned to computer-aided instruction using the algebra program scored higher on a test of pre-algebra and algebra skills than students assigned to traditional instruction (Barrow, Markman, and Rouse 2009).

Internet Access

Access to the Internet is nearly universal in public elementary and secondary schools in the United States. In 2008, 100% of public schools had instructional computers with Internet access (Gray, Thomas, and Lewis 2010). Student access to the Internet via instructional computers at school has increased substantially since 2000. In 2008, the average public school had 189 instructional computers compared with 110 in 2000. There were three students per computer with Internet access in 2008 compared with seven students per computer with Internet access in 2000. Mobile devices are also enhancing students' access to the Internet. Nearly 50% of high school students and 40% of middle school students now own or have access to a smartphone or tablet, marking a 400% increase since 2007 (Project Tomorrow 2012).

Although Internet access is nearly universal, connection speeds and adequate bandwidth are areas of concern (Fox et al. 2012). A 2010 Federal Communications Commission survey of schools with federal funding for Internet access found that most had access to some form of broadband service (Federal Communications Commission 2010). Nearly 80% of survey respondents, however, reported that their broadband connections were inadequate and slow Internet connection speeds were the primary problem. Bandwidth availability and connection speed affect which online content, applications, and functionality students and educators are able to use effectively in the classroom (Fox et al. 2012).

Distance Education and Online Learning

In addition to potentially enhancing learning in the classroom, technology can also enable students to receive instruction remotely through distance education or online learning. Distance education may include videoconferencing and televised or audiotaped courses, but Internet courses (hereafter referred to as online learning) are the most widespread and fastest-growing mode of delivery (Queen and Lewis 2011). Online learning programs range from programs that are fully online with all instruction occurring via the Internet to hybrid or "blended learning" programs that combine face-to-face teacher instruction with online components (Picciano and Seaman 2009; Staker and Horn 2012; Watson et al. 2011).

The United States is experiencing rapid growth in online learning at the K–12 level. The Sloan Consortium estimates that more than 1 million elementary and secondary students were enrolled in online or blended learning courses in 2007–08, a 47% increase from the 2005–06 school year.[34] These estimates are based on two national surveys of public school districts (Picciano and Seaman 2009). Based on this level of growth, the International Association for Online K-12 Learning (iNACOL) estimates that more than 1.5 million K–12 students participated in some form of online learning in 2010 (Wicks 2010). A nationally representative survey of public school districts conducted by NCES in 2009 found that providing courses not otherwise available at their schools and giving students opportunities to recover course credits for classes missed or failed were the top reasons for offering online learning options (Queen and Lewis 2011). The survey found that credit recovery is especially important for urban schools: 81% indicated this was a very important reason for making online learning opportunities available (table 1-14).

Research on Effectiveness of Online Learning

Policymakers and researchers (Bakia et al. 2012; Watson et al. 2012; U.S. Department of Education 2010) cite numerous potential benefits of online learning:

- Increased access to quality educational resources and courses, particularly for students in rural or other remote locations;
- Differentiated instruction based on student need and preferred pace of learning;
- Personalized learning to build on students' interests and increase motivation;
- Reduced costs for school facilities as students access educational resources from home or other community spaces;
- Access to a wider variety of courses, including AP, higher-level math and science, and foreign languages;
- Credit recovery options to assist struggling students and those who need an additional course to graduate;
- Access to international experts to increase knowledge and understanding of careers; and
- Increased access to simulations and virtual field trips.

Table 1-14
Public school districts with students enrolled in distance education courses indicating how important various reasons were for having distance education courses in their district, by district characteristic: School year 2009–10
(Percent)

District characteristic	Provide courses not available at school	Provide opportunity for students to recover course credits from classes missed or failed	Offer Advanced Placement or college-level course	Reduce student scheduling conflicts	Provide opportunities for students who are homebound or have special needs	Provide opportunity for students to accelerate credit accumulation for early graduation
All public school districts with students enrolled in distance education courses	64	57	41	30	25	15
District enrollment size						
< 2,500	69	49	45	28	22	12
2,500–9,999	53	72	33	31	30	20
≥ 10,000	47	81	29	47	41	25
Community type						
City	37	81	23	30	41	29
Suburban	52	66	30	36	35	19
Town	60	60	40	26	30	18
Rural	73	49	48	30	17	11
Region						
Northeast	75	46	39	36	24	11
Southeast	74	65	51	42	25	18
Central	61	59	38	27	26	11
West	56	56	42	26	25	22
Poverty concentration						
< 10%	64	60	36	31	24	15
10%–19%	62	55	43	29	26	14
≥ 20%	65	57	42	31	24	18

NOTES: Response options in the questionnaire were "not important," "somewhat important," "very important," and "don't know." Only the "very important" responses are shown in the table. Percentages are based on the 55% of public school districts with students enrolled in distance education courses in the 2009–10 school year. Poverty estimates for school districts were based on Title I data provided to the U.S. Department of Education by the U.S. Census Bureau.

SOURCE: Queen B, Lewis L, *Distance Education Courses for Public Elementary and Secondary School Students: 2009–10*, NCES 2012-008 (2011).

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Despite the many potential benefits of online learning envisioned by policymakers and researchers, few rigorous studies have addressed the effectiveness of online learning compared with that of traditional school models at the K−12 level (Means et al. 2010). A systematic search of the research literature from 1994 through 2008 identified only five studies published between 1994 and 2008 that rigorously assessed online learning at the K–12 level and only one study (O'Dwyer, Carey, and Kleiman 2007) that assessed the impact of technology on mathematics learning in an elementary classroom in the United States (Means et al. 2010). O'Dwyer et al. (2007) used a quasi-experimental design to compare the learning of 231 students participating in the Louisiana Algebra I Online initiative with the learning of 232 students in comparison classrooms that had similar demographics but used traditional instruction. Scores on matched pretests and posttests showed that the online students performed as well as their peers in conventional classrooms. Other recent studies have found some positive effects for online learning, but researchers stress that teacher training and the way in which online components are integrated into the curriculum are important variables that could affect outcomes and need to be the subject of more rigorous research (Norris, Hossain, and Soloway 2012; Tamin et al. 2011).

Transition to Higher Education

Ensuring that students graduate from high school on time (i.e., within 4 years) and are ready for college or the labor market has been an important goal of high school education in the United States for decades.[35] Increasingly, skills learned in high school do not guarantee access to jobs that support families, because most of the fastest-growing, well-paying jobs in today's labor market require at least some postsecondary education (Carnevale, Smith, and Strohl 2010). About a quarter of U.S. public school students do not graduate from high school with a regular diploma within the expected period of 4 years (Chapman et al. 2011). Among those who do graduate from high school, many go to college or combine school with work, but some enter the labor market without pursuing additional education, at least in the short term (Ingels et al. 2012).

This section updates several indicators related to U.S. students' transitions from high school to college, including on-time high school graduation rates, long-term trends in immediate college enrollment after high school, the high school graduation and postsecondary entry rates of U.S. students relative to those of students in other countries, and remediation rates among students entering postsecondary institutions across the United States. Together, these indicators present a broad picture of the transition of U.S. students from high school to postsecondary education, the topic of chapter 2.

Completion of High School

High school completion in the United States can be defined and measured in a variety of ways (Seastrom et al. 2006). Based on a relatively inclusive definition—receiving a regular high school diploma or earning an equivalency credential, such as a General Educational Development (GED) certificate—about 83% of the U.S. population ages 18–24 had completed a high school education in 2009 (Snyder and Dillow 2012).

Beginning with the 2011–12 school year, the U.S. Department of Education required all states to use a more restricted definition, emphasizing on-time graduation and considering only recipients of diplomas (Curran and Reyna 2010; Chapman et al. 2011). Under this definition, the high school graduation rate is calculated as the percentage of students in a freshman class who graduate with a regular diploma 4 years later (Seastrom et al. 2006). This rate requires student-level data over time. Because not all states had these longitudinal data prior to the 2011−12 school year, the U.S. Department of Education currently uses one of the best estimates—the Averaged Freshman Graduation Rate (AFGR)—to measure on-time high school graduation rates (Seastrom et al. 2006). The AFGR calculation divides the aggregate count of the number of diplomas in a particular year by the estimated size of the incoming freshman class 4 years earlier.[36] Starting with the 2011–12 school year, the U.S. Department of Education required all states to use a measure that is based on student-level data over time in order to increase the accuracy of on-time graduation rates (U.S. Department of Education 2012b). To facilitate state-by-state comparisons, the governors of all 50 states agreed to work toward implementing this method to tabulate statistics for their public high schools (NGA 2005).

On-Time Graduation Rates from 2006 to 2010

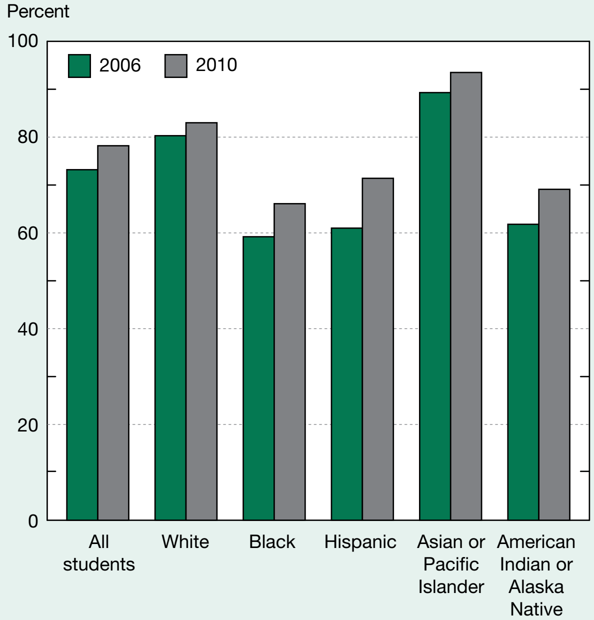
The U.S. on-time graduation rate among public high school students has increased steadily since 2006 (appendix table 1-20). In 2010, 78% of public high school students graduated on time with a regular diploma, up from 73% in 2006 (figure 1-18). Asian or Pacific Islander students (94%) graduated on time at a higher rate than did white students (83%) who, in turn, had a higher on-time graduation rate than did black, Hispanic, and American Indian or Alaska Native students (66%–71%). Between 2006 and 2010, however, on-time graduation rates improved more among black (from 59% to 66%), Hispanic (from 61% to 71%), and American Indian or Alaska Native (from 62% to 69%) students than among white (from 80% to 83%) and Asian or Pacific Islander (from 89% to 93%) students, therefore narrowing the gaps between black, Hispanic, and American Indian or Alaska Native students and their white and Asian or Pacific Islander counterparts.

Sex differences in on-time graduation rates persisted over time (appendix table 1-20). In each year between 2006 and 2009,[37] the percentage of male students who graduated from high school within 4 years was lower than that of female students. In 2009, for example, graduation rates for male students lagged behind those for female students by 8 percentage points (73% versus 81%).

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

Each year, OECD estimates upper secondary graduation rates for its member countries and selected nonmember countries by dividing the number of graduates in a country by the number of people at the typical graduation age (OECD 2012).[38] These estimates enable a broad comparison among nations and illuminate the U.S. standing internationally. U.S. graduation rates are below those of many OECD countries. Of the 26 OECD nations for which graduation rate data were available in 2010, the United States ranked 22nd, with an average graduation rate of 77% compared with the OECD average of 84% (appendix table 1-21). The top-ranked countries include Japan, Greece, Korea, Ireland, Slovenia, Finland, Israel, and the United Kingdom, each of which had high school graduation rates above 90%.[39]

Figure 1-18
On-time graduation rates of U.S. public high school students, by race and ethnicity: 2006 and 2010



NOTES: On-time high school graduation rate is the percentage of entering ninth graders who graduated 4 years later. Hispanic may be any race. American Indian or Alaska Native, Asian or Pacific Islander, black or African American, and white refer to individuals who are not of Hispanic origin.

SOURCES: Stillwell R, Sable J, *Public School Graduates and Dropouts from the Common Core of Data: School Year 2009–10: First Look (Provisional Data)*, National Center for Education Statistics (NCES), NCES 2013-309 (2013); Common Core Data Table Library, https://nces.ed.gov/ccd/tables/AFGR.asp, accessed February 2013. See appendix table 1-20.

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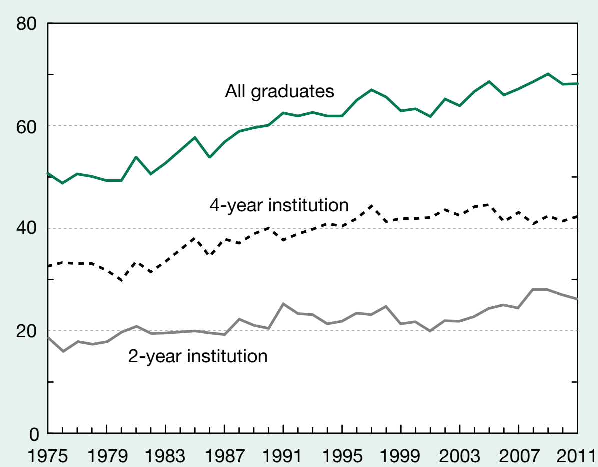
The relative standing of U.S. high school graduation rates has not improved during recent years. Among the 21 OECD countries for which graduation rate data were available in 2006, 2008, and 2010,[40] the United States ranked 16th in both 2006 and 2008 and 17th in 2010 (OECD 2008, 2010, 2012).

Enrollment in Postsecondary Education

Upon completing high school, students make critical choices about the next stage of their lives. Today, a majority of U.S. high school students expect to attend college at some point, and many do so immediately after high school graduation. In 2010, 93% of high school seniors expected to attend a postsecondary institution, with 60% having definite plans to graduate from a 4-year college program and 24% having definite plans to attend graduate or professional school after college (Aud et al. 2012). In 2011, 68% of students enrolled in a postsecondary institution immediately after they graduated from high school (i.e., by the October following high school completion), with 27% enrolling in 2-year colleges and 41% enrolling in 4-year institutions (figure 1-19).

The immediate college enrollment rate increased from 51% in 1975 to 68% in 2011, though the upward trend appeared to level off from 2009 to 2011 (figure 1-19). Overall, immediate college enrollment rose more for women (from

Figure 1-19
Immediate college enrollment rates among high school graduates, by institution type: 1975–2011



NOTES: Includes students ages 16–24 completing high school in survey year. Immediate college enrollment rates are defined as rates of high school graduates enrolled in college in October after completing high school. Before 1992, high school graduates referred to those who had completed 12 years of schooling. As of 1992, high school graduates are those who have received a high school diploma or equivalency certificate.

SOURCE: Aud S, Wilkinson-Flicker S, Kristapovich P, Rathbun A, Wang X, Zhang J, *The Condition of Education 2013*, NCES 2013-037 (2013). See appendix table 1-22.

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49% to 72%) than for men (from 53% to 65%); thus, the enrollment pattern has shifted over time to higher enrollment rates for women than for men (appendix table 1-22).

Large gaps persisted among students of different socioeconomic backgrounds. In each year between 1975 and 2011, the immediate college enrollment rates were lower among students from low-income families than among students from middle- and high-income families (appendix table 1-22). In 2011, the immediate college enrollment rate of students from low-income families was about 29 percentage points lower than the rate of those from high-income families (53% versus 82%). Enrollment rates also varied with parental education, with students whose parents had only a high school education (54%) or some college (67%) trailing behind those whose parents had a bachelor's or advanced degree (83%). Gaps existed among racial and ethnic groups as well. In each year between 1995 and 2011, for example, the enrollment rate of Hispanic students was lower than the rate for white students (e.g., 63% versus 69% in 2011). The immediate college enrollment rate of black students was also lower than the rate for white students in every year from 1995 to 2009 (e.g., 62% versus 71% in 2009).[41]

Postsecondary Enrollment in an International Context

Participation in education beyond secondary schooling has been rising in many countries (Altbach, Reisberg, and Rumbley 2009; OECD 2012). One measure of such participation is the OECD-developed first-time entry rate into a university-level education program (referred to as a "tertiary-type A" program by OECD[42]). This measure, though not perfect,[43] provides a broad comparison of postsecondary enrollment rates in the United States and those in other OECD countries.

According to OECD data, the percentage of U.S. young adults enrolling in university-level education for the first time was 74% in 2010, above the OECD average of 62% (figure 1-20). The United States ranked 9th out of the 30 countries with available data. Women enroll in college at higher rates than men in most OECD countries, including the United States (appendix table 1-23). In the United States, women enrolled at a rate of 82% (compared with the OECD average of 69%), and men enrolled at a rate of 67% (compared with the OECD average of 55%).

Preparation for College

Despite the increasing numbers of U.S. students entering college, many are unprepared for college-level work and need remedial help to address their skill deficiencies (Kurlaender and Howell 2012). Nationally, half of first-time postsecondary students took some type of remedial course after they entered college, and 42% took one or more remedial math courses (table 1-15).[44] The overall remediation rates were much higher at 2-year institutions than at 4-year institutions (65% versus 37%) and at minimally selective 4-year institutions than at highly selective 4-year institutions (53% versus 22%). This variation largely reflects the kinds of students admitted to different types of institutions: 4-year colleges, particularly highly selective ones, tend to admit students with greater academic preparation than more accessible 2-year colleges, and this pattern, in turn, affects the number of students needing remedial education at these institutions (Berkner and Choy 2008).

Figure 1-20
First-time entry rates into university-level education, by OECD country: 2010

OECD = Organisation for Economic Co-operation and Development.

NOTES: Portugal's rate was overestimated because it included students who enrolled in the first year of any postsecondary program instead of a university-level education program. Countries/jurisdictions are ordered by 2010 first-time entry rate. Tied countries/jurisdictions with identical rounded estimates are listed alphabetically.

SOURCE: OECD, *Education at a Glance: OECD Indicators 2012* (2012). See appendix table 1-23.

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Table 1-15
Beginning 2003–04 postsecondary students who took remedial courses during their enrollment, by type of first institution: 2003–09
(Percent)

Type of first institution	One or more remedial courses in any field	One or more remedial mathematics courses
All beginning postsecondary students	50.4	42.2
4-year institution[a]	37.2	29.2
Highly selective	22.4	15.0
Moderately selective	37.1	29.4
Minimally selective or open admission	53.4	44.7
2-year institution	65.4	57.1

[a] A small proportion of students who first attended private, for-profit 4-year institutions were excluded from the estimates that are based on institution selectivity because information on the selectivity of these institutions was not available.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, special tabulations (2012) of 2003–04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09), National Center for Education Statistics.

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Conclusion

Raising student achievement, reducing performance gaps, and improving the international ranking of U.S. students on achievement tests from the middle to the top are high priorities for education reform across the United States. How well does this country perform in these areas? The indicators in this chapter present a mixed picture of the progress of elementary and secondary mathematics and science education in the United States. NAEP mathematics assessment results show that average mathematics scores for fourth and eighth graders have increased substantially since 1990, but this improvement has slowed down or halted for many groups in recent years. In science, eighth graders made small gains from 2009 to 2011. Overall, a large majority of U.S. fourth and eighth graders did not demonstrate proficiency in the knowledge and skills taught at their grade level. In particular, students from disadvantaged backgrounds lagged behind their more advantaged peers, with these disparities starting as early as kindergarten. International assessments have also produced mixed results. Although U.S. students have performed above the international average on the TIMSS mathematics and science tests, they have not been among the very top-achieving groups in the world.

Efforts to improve student achievement include raising high school graduation requirements, strengthening the rigor of curriculum standards, increasing advanced coursetaking, and promoting early participation in gatekeeper courses such as algebra 1. These efforts have brought some positive changes: increasing numbers of states adopted a common set of rigorous academic standards designed to ensure that students graduate from high school prepared for college and careers; rising proportions of students earned advanced mathematics and science credits before high school completion; large majorities of ninth graders took algebra 1 during or before their freshman year; and the number of students taking mathematics and science AP exams doubled in the recent decade. There is still room for improvement, however: the overall percentage of students taking mathematics and science AP tests remains very small; a sizeable number of students do not take any math or science in their freshman year; and wide gaps among students from different social and economic backgrounds persist.

Efforts to improve student achievement also focus on ensuring that all students have access to highly qualified teachers, although there has not yet been a consensus on what constitutes a “highly qualified” teacher. The majority of K−12 mathematics and science teachers held a teaching certificate and had taught their subjects for 3 or more years. Indicators of in-field teaching and undergraduate coursework suggest that high school mathematics and science teachers were generally better prepared for their teaching subjects than middle and elementary school teachers. Fully certified, well-prepared, and experienced teachers were not evenly distributed across schools or classes. Overall, schools or classes with lower concentrations of non-Asian minority and low-income students and higher concentrations of high-achieving students were more likely to have fully certified and better-prepared mathematics and science teachers. Working conditions were also not evenly distributed across schools: high-poverty schools were more likely to suffer from various problems that inhibit effective teaching (e.g., low student interest, high absenteeism, inadequate teacher preparation, and lack of materials and supplies).

The majority of middle and high school mathematics and science teachers participated in subject-focused professional development activities, but elementary science teachers were far less likely to do so. Many teachers reported that their professional development activities were of short duration, lasting in total from less than 6 hours to 35 hours during the past 3 years. About a quarter of secondary mathematics and science teachers left teaching within 3 years of entering the profession; this attrition rate was more than double the rate for other secondary-level teachers.

Recent federal and state policies encourage greater use of technology throughout the education system as a way to improve students’ learning experience. The use of instructional technology in K−12 classrooms has been growing at a rapid pace. Many school districts have invested in technology such as computers and mobile devices. The number of students participating in online learning courses is also rising, jumping from 220,000 in 2003 to an estimated 1.8 million in 2010. Rigorous research on the effects of instructional technology and online learning has just begun, showing some modest positive effects on student mathematics learning, but far more research is needed to determine which technologies are effective and under what conditions.

Ensuring that students graduate from high school and are ready for college or the labor market is an important goal of high school education in the United States. Since 2006, the U.S. on-time high school graduation rates have improved steadily. In 2010, the vast majority of public high school students graduated with a regular diploma 4 years after entering ninth grade. Significant racial and ethnic and sex differences persisted, however, with white, Asian or Pacific Islander, and female students having higher graduation rates than their counterparts. In the broad international context, the United States ranked 22nd in graduation rates among 26 OECD countries with available data in 2010, and its relative standing has not improved in recent years.

The vast majority of high school seniors expect to attend college after completing high school, and many do so directly after high school graduation. Immediate college enrollment rates have increased for all students as well as for many demographic groups since 1975, although this upward trend leveled off somewhat from 2009 to 2011. Wide gaps have persisted, with black students, Hispanic students, low-income students, and students whose parents have less education enrolling in college at lower rates than their peers. Large proportions of college entrants, particularly those beginning at 2-year or minimally selective 4-year institutions, took remedial courses to address their skill deficiencies in mathematics and other areas.

Notes

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

2. The No Child Left Behind Act of 2001 has been due for congressional reauthorization since 2007. President Obama announced in September 2011 that his administration would grant waivers from NCLB requirements to states in exchange for state-developed reform plans to prepare all students for college and career, focus aid on the neediest students, and support effective teaching and leadership. As of October 2012, 44 states had requested waivers from NCLB and 33 states (plus the District of Columbia) had been approved to implement their state-tailored reform agendas. The 33 approved states include Arizona, Arkansas, Colorado, Connecticut, Delaware, Florida, Georgia, Indiana, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, New Jersey, New Mexico, New York, North Carolina, Nevada, Ohio, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Tennessee, Utah, Virginia, Washington, and Wisconsin. The 11 states with outstanding requests for waivers include Alabama, Alaska, California, Hawaii, Idaho, Illinois, Iowa, Maine, New Hampshire, North Dakota, and West Virginia. The 6 states that have not yet requested a waiver include Montana, Nebraska, Pennsylvania, Texas, Vermont (request withdrawn), and Wyoming (http://www.ed.gov/news/press-releases/seven-more-states-puerto-rico-and-bureau-indian-education-request-nclb-flexibili).

3. Whenever a difference is cited in this chapter, it was tested using Student's t-test statistic to minimize the chances of concluding that the 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 0.1, which means that a reported difference would occur by chance no more than once in 10 samples when there was no actual difference between the population means.

4. No new assessment data on high school students were available at the time this chapter was prepared. The 2012 volume of *Science and Engineering Indicators* (NSB 2012) contains recent trend data on mathematics and science performance of students in grade 12.

5. Asians and Pacific Islanders are combined into one category in some indicators for which the data were not collected separately for the two groups.

6. Mathematics assessments were administered in fall 2010 and spring 2011. These assessments were designed to measure students' conceptual knowledge, procedural knowledge, and problem-solving skills and included questions on number sense, properties, and operations; measurement; geometry and spatial sense; data analysis, statistics, and probability; and pre-algebra skills (Mulligan, Hastedt, and McCarroll 2012). Although the assessments included largely items related to students' knowledge at the kindergarten level, easier and more difficult items were included to measure the achievement of students performing below or above grade level. Some students who spoke a language other than English or Spanish at home did not participate in mathematics assessments because of low English proficiency. Because the ECLS-K:2011 is a longitudinal study, the assessments were developed to measure the growth in performance of children from kindergarten entry through fifth grade.

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

8. 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 assessments in mathematics were administered again in 2012 and are not yet available; no long-term trend assessments in science have been conducted since 1999.

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

10. 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.

11. Estimates for long-term trends could not be performed for American Indian or Alaska Native students because of unavailable data in the 1990s.

12. Percentiles are scores below which the scores of a specified percentage of the population fall. For example, among fourth graders in 2011, the 10th percentile score for mathematics was 203. This means that 10% of fourth graders had mathematics scores at or below 203, and 90% scored above 203. The scores at various percentiles indicate students' performance levels.

13. Students' eligibility for free/reduced-price lunch is often used as a proxy measure of family poverty. In this chapter, students who are eligible for free/reduced-price lunch are considered to come from low-income families.

14. For fourth and twelfth graders' science assessment results in 2009, see *Science and Engineering Indicators 2012* (NSB 2012:1-13). For results from administration years prior to 2009, see *Science and Engineering Indicators 2008* (NSB 2008:1-13–1-14).

15. The substantive implication of this small increase will be clearer when more assessment data are available for analysis in the future.

16. Differences in performance between public and private school students reflect in part different types of students enrolled in public and private schools and differences in the availability of resources, admissions policies, level of parental involvement, and school conditions.

17. For detailed comparisons between PISA and TIMSS, see *Science and Engineering Indicators 2010* (NSB 2010:1–16).

18. For more information about the PISA results, see *Science and Engineering Indicators 2012* (NSB 2012:1-14–1-16).

19. The scores are reported on a scale from 0 to 1,000, with the TIMSS scale average set at 500 and the standard deviation set at 100.

20. The TIMSS results presented in this report exclude individual U.S. states, Canadian provinces, and Dubai and Abu Dhabi in the United Arab Emirates. These states/provinces participated in 2011 TIMSS as "benchmarking participants" in order to assess the comparative international standing of their students' achievement and to view their curriculum and instruction in an international context.

21. Taipei is the capital city of Taiwan.

22. The TIMSS scale for each subject and grade originally was established to have a mean of 500 as the average of all of the countries and jurisdictions that participated in TIMSS 1995. TIMSS assessments since then have scaled the achievement data so that scores are comparable from assessment to assessment. Thus, for example, a score of 500 in fourth grade mathematics in 2011 is equivalent to a score of 500 in fourth grade mathematics in 1995, 1999, 2003, or 2007.

23. The transcript studies reported in 2012 have not been updated since then.

24. A recent NCES study of algebra and geometry curricula in the nation's high schools found substantial variation in rigor and curriculum coverage among these courses (Brown et al. 2013). For more information, see http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2013451.

25. NCES established the Secondary Longitudinal Studies Program (SLSP) to study the educational, vocational, and personal development of young people beginning with their high school years and following them over time into adult roles and responsibilities. Thus far, the SLSP consists of five major studies: the National Longitudinal Study of the High School Class of 1972 (NLS:72); High School and Beyond (HS&B); the National Education Longitudinal Study of 1988 (NELS:88); the Education Longitudinal Study of 2002 (ELS:2002); and the High School Longitudinal Study of 2009 (HSLS:09). More information about each of these studies is available at http://nces.ed.gov/surveys/slsp.

26. The first follow-up collection of HSLS:09 was conducted in spring 2012 when most sample members were in the eleventh grade. Data from this collection were not available at the time of publication. Future follow-ups will include collection and coding of high school transcripts in 2013 and a second follow-up in 2016 when most sample members will be 3 years beyond high school graduation. Additional follow-ups are currently planned to at least age 26.

27. It is important to note that the data from HSLS indicate the percentage of students who enrolled in algebra in ninth grade but not the percentage who passed the course.

28. NAEP HSTS identifies three curriculum levels based on the types of courses students take: standard, midlevel, and rigorous. A rigorous mathematics curriculum includes 4 years of mathematics including up to at least pre-calculus (Nord et al. 2011).

29. Socioeconomic status (SES) is a composite variable derived from parental education level, parental occupation, and family income. The quintile measure divides the SES distribution into five equal groups. Quintile 1 corresponds to the lowest one-fifth of the population and quintile 5 corresponds to the highest. For this report, the middle three quintiles are combined to form one category.

30. White students were equally likely to report enrollment in biology 1 or earth/environmental/physical science in ninth grade (36% each), whereas students in other racial and ethnic groups were more likely to report enrollment in biology 1: 35% of black students and 44% of Hispanic students reported enrollment in biology 1 compared with 27% and 24%, respectively, in earth/environmental/physical science. Asian students were the most likely to report enrollment in biology 1 (51%) and the least likely to report enrollment in environmental/physical science (17%). Research does not indicate why this coursetaking pattern is different for whites compared with other groups.

31. In previous editions of *Science and Engineering Indicators*, data from the NCES Schools and Staffing Survey (SASS) have been used to describe teachers and teaching. The 2011−12 SASS data were not available for analyses at the time this chapter was prepared, however.

32. The NSSME reports the percentage of mathematics teachers who have a degree in mathematics or mathematics education and the percentage of science teachers who have a degree in science (any subject), engineering, or science education. Teachers of mathematics with related degrees, such as computer science or physics are not included in the percentage of mathematics teachers with degrees in their field. The NSSME provides further level of detail for science teachers, indicating the percentage of teachers of each discrete science subject that have a degree in that particular area.

33. Effect sizes ranged from +0.1 to +0.2, indicating a difference of .1 to .2 standard deviations, generally considered small effect sizes.

34. Public school enrollment in K−12 in the United States in 2008 was approximately 49 million students (http://nces.ed.gov/fastfacts/display.asp?id=65).

35. See the U.S. Education Dashboard at http://dashboard.ed.gov/about.aspx.

36. The incoming freshman class size is estimated by summing the enrollment in eighth grade for 1 year, ninth grade for the next year, and tenth grade for the year after, and then dividing by 3. For example, the 2009–10 on-time graduation rate equals the total number of diploma recipients in 2009–10 divided by the average membership of the eighth grade class in 2005–06, the ninth grade class in 2006–07, and the tenth grade class in 2007–08 (Stillwell and Sable 2013).

37. Gender data were not available in 2010.

38. Upper secondary education as defined by OECD corresponds to high school education in the United States. In the calculation of the U.S. graduation rates, OECD included only students who earned a regular diploma and excluded those who completed a GED certificate program or other alternative forms of upper secondary education. OECD defines the typical age as the age of the students at the beginning of the school year; students will generally be 1 year older than the age indicated when they graduate at the end of the school year. According to OECD, the typical graduation age in the United States is 17 years old. The U.S. high school graduation rates calculated by OECD cannot be directly compared with U.S. on-time graduation rates because of the different population bases and calculation methods for the two measures.

39. Portugal's rate, though at the top, was not reliable and therefore is not listed here.

40. These countries are Czech Republic, Denmark, Finland, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Norway, Poland, Slovak Republic, Spain, Sweden, Turkey, the United Kingdom, and the United States.

41. The 2011 immediate college enrollment rates for whites and blacks were not measurably different (69% and 65%, respectively).

42. As defined by OECD, a "tertiary-type A" program provides education that is largely theoretical and is intended to provide sufficient qualifications for gaining entry into advanced research programs and professions with high-skill requirements. Entry into these programs normally requires successful completion of upper secondary education (e.g., high school); admission is competitive in most cases. Minimum cumulative duration at this level is 3 years of full-time enrollment.

43. International comparisons are often difficult because of differences between education systems, types of degrees awarded across countries, and definitions used in different countries. Some researchers have pinpointed various problems and limitations of international comparisons and warned readers to interpret data including those published by OECD with caution (Adelman 2008; Wellman 2007).

44. The data are from the U.S. Department of Education's 2003–04 Beginning Postsecondary Longitudinal Study (BPS:04/09). This national, longitudinal study examines students who first began their postsecondary education in the 2003–04 academic year and follows them for 6 years through 2009. Students are considered to have participated in remedial education if they took a remedial course at some point during these 6 years according to their postsecondary transcripts.

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.

Organisation for Economic Co-operation and Development (OECD): An international organization of 34 countries headquartered in Paris, France. The member countries are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Estonia, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. Among its many activities, the OECD compiles social, economic, and science and technology statistics for all member and selected non-member countries.

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 2011 in NAEP.

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 Mathematics and Science

Advanced Placement (AP): 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.

Teachers of Mathematics and Science

Elementary schools: Schools that have no grades higher than 8.

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

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

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.

Instructional Technology and Digital Learning

Blended learning: Any time a student learns at least in part at a supervised, traditional school location away from home and at least in part through online delivery with some element of student control over time, place, path, and/or pace; often used synonymously with "hybrid learning."

Distance education: A mode of delivering education and instruction to students who are not physically present in a traditional setting such as a classroom. Also known as "distance learning," it provides access to learning when the source of information and the learners are separated by time and/or distance.

Online learning: Education in which instruction and content are delivered primarily over the Internet.

Transition to Higher Education

GED certificate: This award is received following successful completion of the General Educational Development (GED) test. The GED program, sponsored by the American Council on Education, enables individuals to demonstrate that they have acquired a level of learning comparable to that of high school graduates.

High school completer: An individual who has been awarded a high school diploma or an equivalent credential, including a GED certificate.

High school diploma: A formal document regulated by the state certifying the successful completion of a prescribed secondary school program of studies. In some states or communities, high school diplomas are differentiated by type, such as an academic diploma, a general diploma, or a vocational diploma.

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.

Remedial courses: Courses taught within postsecondary education that cover content below the college level.

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Errata

The following errors were discovered after publication of the print and PDF versions of *Science and Engineering Indicators 2014*. These errors have been corrected in the online version of the volume.

Updated 21 April 2014

Science and Engineering Indicators 2014
Chapter 1

Page 1-4. The percentages of ninth-grade students enrolled in science courses were reported incorrectly in the chapter highlights. The correct values are 39% for biology 1 and 31% for earth/environmental/physical sciences.