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Are All Students Getting Equal Access to High-Quality Science Education? Data From the 2018 NSSME+

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Additional Information

More details and products from the 2018 NSSME+, as well as previous iterations of the study, can be found at: http://horizon-research.com/NSSME/

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Introduction

In 2018, the National Science Foundation supported the sixth in a series of surveys through a grant to Horizon Research, Inc. (HRI). The first survey was conducted in 1977 as part of a major assessment of science and mathematics education and consisted of a comprehensive review of the literature; case studies of 11 districts throughout the United States; and a national survey of teachers, principals, and district and state personnel. A second survey of teachers and principals was conducted in 1985–86 to identify trends since 1977. A third survey was conducted in 1993, a fourth in 2000, and a fifth in 2012. This series of studies has been known as the National Survey of Science and Mathematics Education (NSSME). The 2018 NSSME+[1] was designed to provide up-to-date information and to identify trends in the areas of teacher background and experience, curriculum and instruction, and the availability and use of instructional resources.[2]

Prior research has shown that students' educational opportunities and experiences are shaped by a number of factors. Social inequalities originating outside of schools have consequences for students' classroom-based learning opportunities and their achievement.[3] Schools, once thought to "level the playing field" by providing equal learning opportunities for students of all backgrounds, are themselves unequally resourced in terms of material resources available for instruction, the qualifications of the teachers, school programs and practices to support effective instruction, and, consequently, the nature of instruction students receive. Historically, the unequal distribution of these resources has resulted in inequitable learning opportunities and outcomes for different groups of students.[4]

Although not designed primarily as an equity study, the 2018 NSSME+ provides data on some indicators of the extent to which students across the nation have equitable educational opportunities. To this end, data from the study were analyzed by four factors historically associated with differences in educational opportunities. These "equity factors" fall into two

[1] Banilower, E. R., Smith, P. S., Malzahn, K A., Plumley, C L., Gordon, E M., & Hayes, M. L. (2018). *Report of the 2018 NSSME+*. Horizon Research, Inc.

[2] Complete details of the study—sample design, sampling error considerations, instrument development, data collection, file preparation and analysis, and composite definitions—as well as copies of the instruments, are included in the technical report, which is available free of charge at: http://horizon-research.com/NSSME/2018-nssme/research-products/reports/technical-report.

[3] Denton, K., & West, J. (2002). *Children's reading and mathematics achievement in kindergarten and first grade*. Retrieved August 23, 2018 from https://nces.ed.gov/pubs2002/2002125.pdf.

Duncan, G. J. & Murnane, R. J. (Eds.) (2011). *Whither opportunity? Rising inequality, schools, and children's life chances*. Russell Sage Foundation.

Rothstein, R. (2004). *Class and schools: Using social, economic, and educational reform to close the black-white achievement gap*. Economic Policy Institute.

Jordan, N. C., Kaplan, D., Olah, L. N., & Locuniak, M. N. (2006). Number sense growth in kindergarten: A longitudinal investigation of children at risk for mathematics difficulties. *Child Development*, *77*, 153–175.

National Center for Education Statistics. (2000). *America's kindergartners*. Retrieved August 23, 2018 from https://nces.ed.gov/pubs2000/2000070.pdf.

[4] Campbell, J. R., Hombo, C. M., & Mazzeo, J. (2000). *NAEP 1999 trends in academic progress: Three decades of student performance.* Department of Education, National Center for Education Statistics.

Kozol, J. (1991). *Savage inequalities: Children in America's schools*. Crown.

Oakes, J., Ormseth, T., Bell, R., & Camp, P. (1990). *Multiplying inequalities: The effects of race, social class, and tracking on opportunities to learn mathematics and science.* Rand Corp.

Smith, P. S., Trygstad, P. J., & Banilower, E. R. (2016). Widening the gap: Unequal distribution of resources for K–12 science instruction. *Education Policy Analysis Archives*, *24*(8), 1–42.

categories, those associated with school characteristics and those associated with the composition of classes.[5]

- **Percentage of students in the school eligible for free/reduced-price lunch (FRL)**
  Each school was classified into 1 of 4 categories based on the percentage of students eligible for free/reduced-price lunch (FRL). Defining common categories across grades K–12 would have been misleading, as students tend to select out of the FRL program as they advance in grade due to perceived social stigma. Therefore, the categories were defined as quartiles within groups of schools serving the same grades (e.g., schools with grades K–5, schools with grades 6–8). Cut points for these quartiles are included in Appendix A.

- **Community type**
  Schools were coded into 1 of 3 types of communities:

  - Urban: central city;
  - Suburban: area surrounding a central city, but still located within the counties constituting a Metropolitan Statistical Area (MSA); or
  - Rural: area outside any MSA.

- **Percentage of students in the class from race/ethnicity groups historically underrepresented in STEM (HUS)**
  Each randomly selected class was classified into 1 of 4 quartiles based on the percentage of students in the class from race/ethnicity groups historically underrepresented in STEM (i.e., American Indian or Alaskan Native, Black or African American, Hispanic or Latino, Native Hawaiian or Other Pacific Islander, multi-racial); gender is not a part of this factor. Cut points for these quartiles are included in Appendix A.

- **Prior achievement level of the class**
  Based on teacher-provided information,[6] classes were coded into 1 of 3 categories, composed of:

  - Mostly low-prior-achieving students;
  - Mostly average-prior-achieving students/a mixture of levels; or
  - Mostly high-prior-achieving students.

Organization of This Report

This report is organized by equity factor, with each chapter highlighting the distribution of four educational resources among K–12 schools and classrooms in the United States:

[5] It is important to note that, to varying degrees, these factors are correlated. For example, classes containing higher percentages of students from race/ethnicity groups historically underrepresented in STEM are more likely to be located in schools with higher percentages of students eligible for free/reduced-price lunch (in addition to being more likely to be classified as low-prior-achieving students). Urban schools tend to have higher percentages of free/reduced-price lunch and historically underrepresented students than suburban and rural schools.

[6] Because it was not feasible for the NSSME+ to collect student data, the only way to gather nationally representative data about students' prior achievement was by relying on teacher report. However, it is important to recognize that multiple factors can influence teachers' perceptions of students and what they have or have not achieved in the past.

- Nature of instruction;
- Material resources;
- Well-prepared teachers; and
- Supportive context for learning.

Data from the 2018 NSSME+, both individual items and composite variables,[7] are shown in tables, with the standard errors for the estimates included in parentheses. Within each equity factor, comparisons were made between groups. For FRL and HUS, comparisons were made between the highest and lowest quartiles. For prior achievement, comparisons were made between classes of mostly low-prior-achieving students and classes of mostly high-prior-achieving students. For community type, comparisons were made among all three community types (urban vs. suburban, urban vs. rural, and rural vs. suburban), using the False Discovery Rate method[8] to maintain an overall Type I error rate of five percent. Statistically significant differences ($p < 0.05$) are denoted by asterisks in the tables.

In addition, when possible, data from the 2018 and 2012[9] studies were compared to examine whether the magnitude of differences between groups changed across the two time points.[10] Statistically significant changes over time are illustrated in figures. However, it is important to note that even though the data might be the same in 2012 and 2018, there may still have been significant differences within years.

[7] Composite variables have the advantage of being more reliable than individual items. Each composite was calculated by summing the responses to the relevant items and then dividing by the total points possible. Composite scores can range from 0 to 100 points; someone who marks the lowest point on every item in a composite receives a score of 0, and someone who marks the highest point on every item receives a score of 100.

[8] The false discovery rate method adjusts the alpha level required for statistical significance. Benjamini, Y. & Hochberg, Y. (1995). Controlling the false discovery rate: a practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society,* B, 57, 289–300.

[9] Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 National Survey of Science and Mathematics Education.* Horizon Research, Inc.

[10] The wording of some survey items changed slightly between 2012 and 2018. Items included in both studies, and those similar enough to be considered trend, are denoted by a "(t)" in tables. Additionally, some composite variables were computed differently for this report than in an individual year's report to allow for comparisons between the two time points. Details about item wording and composite definition changes between 2012 and 2018 can be found in Appendices B and C, respectively.

Free/Reduced-Price Lunch

This chapter of the report examines differences in data from the study by the socioeconomic status of students served by schools (measured by percentage of students eligible for FRL), specifically comparing schools with the largest percentages to schools with the smallest percentages of FRL-eligible students.[11] As described in the introduction, schools were classified into quartiles created within groups of schools by grades served (e.g., schools with some or all grades K–5, schools with some or all grades 6–8). As can be seen in Table 2.1, schools in the highest quartile had an average of 95 percent of students eligible for FRL, and schools in the lowest quartile had an average of 11 percent of students eligible for FRL.

Table 2.1
Average Percentage of Students in School Eligible for FRL in Each Quartile

	PERCENT FRL
Lowest Quartile Schools	11 (0.8)
Second Quartile Schools	37 (0.9)
Third Quartile Schools	61 (0.8)
Highest Quartile Schools	95 (0.5)

Nature of Science Instruction

Student opportunity to learn science is a function of both access to science instruction (courses at the secondary level) and the nature of instruction they receive. The 2018 NSSME+ collected data about science instruction, including time spent on science in the elementary grades and science course offerings at the high school level. Science teachers were also asked about: (1) their perceptions of autonomy in making curricular and instructional decisions, (2) instructional objectives and class activities they use in accomplishing these objectives, and (3) how student performance is assessed. This section of the report presents these data, highlighting the similarities and differences between high-FRL schools and low-FRL schools.

Time Spent on Various Subjects In Elementary Grades

The amount of instruction devoted to a subject is an important component of students' opportunity to learn. Table 2.2 shows the average number of minutes per day typically spent on science, reading/language arts, mathematics, and social studies in elementary grades self-contained classes that cover all four subjects. Classes in the highest quartile of schools and lowest quartile of schools spent an average of approximately 20 minutes per day on science instruction. However, time spent on science instruction was substantially less than time spent on reading/language arts or mathematics. When looking at trends over time, the 2018 data are not significantly different from the 2012 data.

[11] Throughout this chapter, schools with the largest percentage and the smallest percentage of students eligible for FRL are referred to as high- and low-FRL schools, highest and lowest quartile schools, and high- and low-poverty schools.

Table 2.2
Average Number of Minutes Per Day Spent Teaching Each Subject in Elementary Grades Self-Contained Classes,[a] by FRL Quartile†

	NUMBER OF MINUTES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Reading/Language Arts	83 (2.8)	92 (4.0)	93 (3.6)	87 (5.0)
(t) Mathematics	52 (1.7)	62 (2.8)	62 (2.1)	56 (3.3)
(t) Science	18 (1.3)	19 (1.6)	17 (1.1)	20 (1.3)
(t) Social Studies	17 (1.0)	16 (1.1)	15 (0.9)	17 (1.1)

(t) Trend item

† There are no statistically significant differences between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p \geq 0.05$).

a Includes only classes taught by self-contained elementary teachers who indicated they teach reading, mathematics, science, and social studies to one class of students.

Course-Taking Opportunities in High School

At the high school level, teachers were asked to provide information about a randomly selected class, including the course type, which allows for an estimate of the percentage of science courses of each type in schools. As can be seen in Table 2.3, the distribution of courses is significantly different between classes in the highest and lowest FRL quartiles. This difference is likely due to two factors. First, it appears that classes in the highest quartile of schools were more likely than classes in the lowest quartile to be at the non-college prep level. Second, it seems that classes in the highest quartile of schools were less likely than classes in the lowest quartile to be at the advanced level. These data are not significantly different from the 2012 data.

Table 2.3
Prevalence of High School Science Courses, by FRL Quartile(t)

	PERCENT OF CLASSES*			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
Non-college prep	20 (2.5)	23 (2.8)	31 (3.3)	38 (3.7)
1st year biology	21 (2.6)	25 (2.8)	22 (3.5)	21 (3.4)
1st year chemistry	18 (1.9)	14 (1.5)	15 (2.3)	16 (2.0)
1st year physics	9 (1.5)	9 (1.5)	8 (1.4)	7 (1.8)
1st year multi-discipline science courses	3 (1.0)	6 (2.0)	7 (2.1)	7 (1.5)
1st year Earth/space science	3 (1.1)	2 (0.9)	1 (0.8)	1 (0.6)
1st year environmental science	3 (1.8)	1 (0.5)	3 (1.2)	1 (0.6)
Advanced science courses	23 (3.3)	20 (3.0)	14 (2.3)	10 (2.1)

(t) Trend item

* There is a statistically significant difference in the distribution between classes in the lowest quartile of schools and those in the highest quartile of schools (Chi-square test of independence, $p < 0.05$).

Teachers' Perceptions of Their Decision-Making Autonomy

Many in education believe that classroom teachers are in the best position to know their students' needs and interests and, therefore, should be the ones making decisions about tailoring instruction to a particular group of students. Accordingly, the survey asked teachers about the extent to which they had control over a number of curriculum and instruction decisions for their classes.

As can be seen in Table 2.4, classes, regardless of school poverty level, were likely to be taught by teachers who perceived themselves as having strong control over some pedagogical decisions, but not others. For example, teachers in about two-thirds of classes in both high-poverty and low-poverty schools felt strong control over determining the amount of homework to be assigned. In contrast, teachers of classes in high-poverty schools were less likely than their counterparts in low-poverty schools to feel strong control over selecting teaching techniques (47 vs. 62 percent), choosing criteria for grading student performance (47 vs. 62 percent), or determining the amount of instructional time to spend on each topic (24 vs. 37 percent).

Teachers' perceptions of control over curricular decisions show a somewhat similar pattern. About one-fourth of classes in the highest and lowest quartiles of schools were taught by teachers who considered themselves to have strong control over determining course goals and objectives. However, only 28 percent of classes in the highest quartile of schools, compared to 40 percent of classes in the lowest quartile, were taught by teachers who perceived this same level of control in selecting the sequence in which topics are covered. In addition, teachers of classes in the highest quartile of schools were less likely than their counterparts in the lowest quartile to have strong control over selecting curriculum materials (12 vs. 27 percent) or selecting content, topics, and skills to be taught (15 vs. 24 percent).

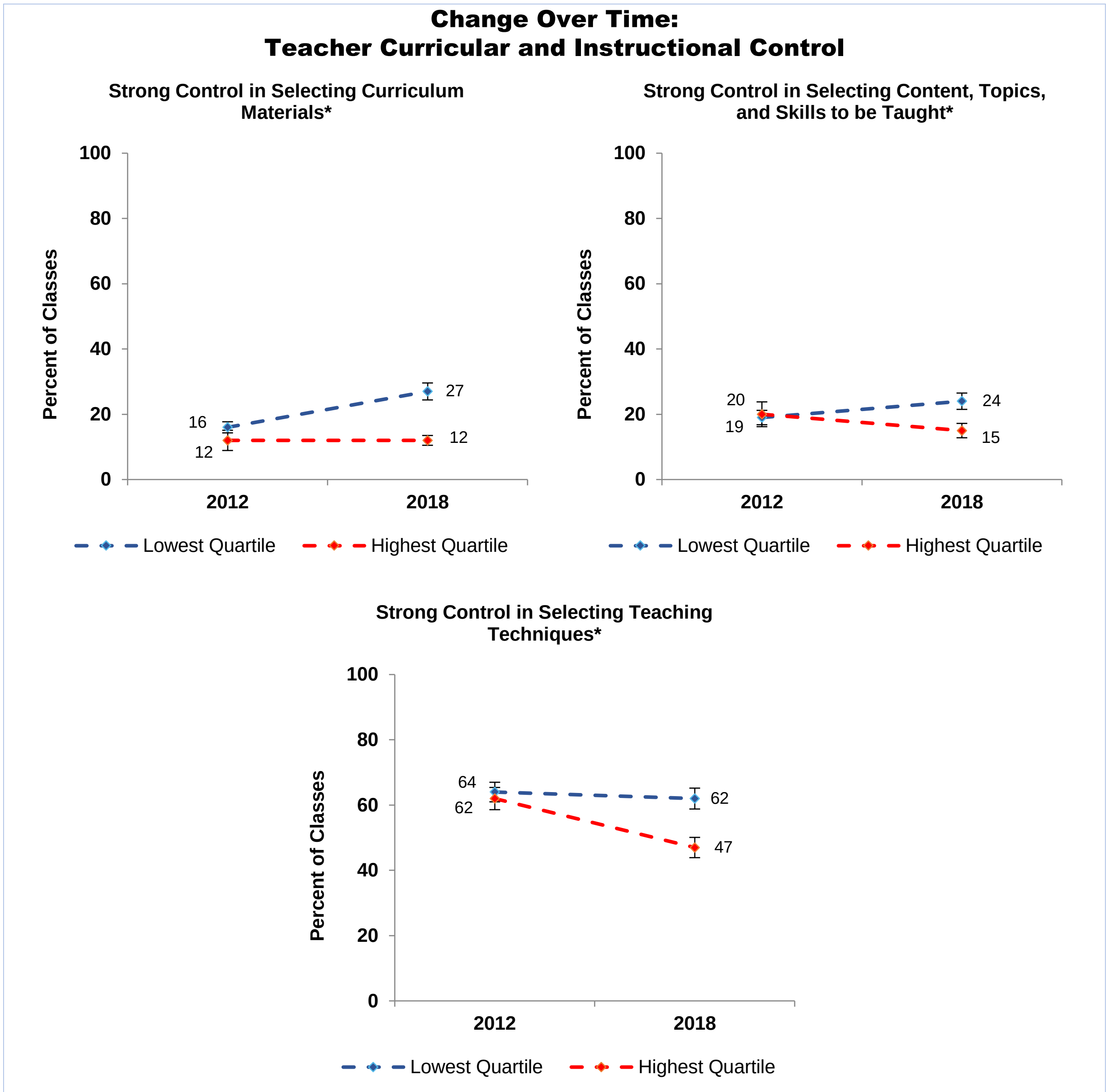
Table 2.4
Science Classes in Which Teachers Felt Strong Control Over Various Curricular and Instructional Decisions, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Determining the amount of homework to be assigned	66 (3.1)	67 (2.8)	70 (3.0)	61 (3.2)
(t) Selecting teaching techniques*	62 (3.2)	61 (2.6)	59 (3.0)	47 (3.1)
(t) Choosing criteria for grading student performance*	50 (2.8)	52 (3.1)	50 (3.3)	41 (3.2)
Selecting the sequence in which topics are covered*	40 (2.8)	38 (3.0)	44 (3.9)	28 (3.3)
Determining the amount of instructional time to spend on each topic*	37 (2.7)	34 (2.8)	36 (4.1)	24 (2.9)
(t) Determining course goals and objectives	27 (2.5)	27 (2.8)	27 (4.1)	21 (2.6)
(t) Selecting content, topics, and skills to be taught*	24 (2.5)	23 (2.8)	23 (4.3)	15 (2.2)
(t) Selecting curriculum materials (e.g., textbooks/online courses)*	27 (2.6)	25 (2.2)	29 (4.2)	12 (1.5)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

Figure 2.1 shows significant changes over time between classes in high-FRL and low-FRL schools in teachers' perceptions of strong control over pedagogical and curricular decisions. In each case, there is a widening of the gap. In terms of curricular control, the percentage of classes in high-FRL schools taught by teachers who felt strong control in selecting curriculum materials did not change from 2012 to 2018 (12 percent), but the percentage classes in low-FRL schools taught by teachers who felt strong control in selecting curriculum materials increased (16 vs. 27 percent). Additionally, in 2012, 20 percent of classes in high-FRL schools and 19 percent in low-FRL schools were taught by teachers who felt strong control over selecting the content, topics, and skills to be taught, compared to 15 and 24 percent of classes in 2018, respectively. Looking at pedagogical control, the percentage of classes in high-FRL schools taught by teachers who felt strong control over selecting teaching techniques decreased from 2012 to 2018 (62 vs. 47 percent), while the percentage of classes in low-FRL schools taught by teachers who felt strong control in this area changed very little (64 vs. 62 percent).



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

Figure 2.1

The items in Table 2.4 were combined into two composite variables—Curriculum Control and Pedagogy Control. Curriculum Control consists of the following items:

- Determining course goals and objectives;
- Selecting curriculum materials;
- Selecting content, topics, and skills to be taught; and
- Selecting the sequence in which topics are covered.

For Pedagogy Control, the items are:

- Selecting teaching techniques;
- Determining the amount of homework to be assigned; and
- Choosing criteria for grading student performance.

Table 2.5 shows the mean scores on these composites by school poverty level. These scores indicate that teachers of classes in high-poverty schools tended to feel less control over decisions related to curriculum and pedagogy than their counterparts in low-poverty schools. These data are not significantly different from the data in 2012.

Table 2.5
Science Class Mean Scores for Curriculum Control and Pedagogy Control Composites, by FRL Quartile

	MEAN SCORE			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Curriculum Control*,a	56 (1.8)	56 (2.2)	55 (3.1)	47 (1.8)
(t) Pedagogy Control*	84 (1.4)	85 (1.3)	84 (1.4)	79 (1.5)

(t) Trend composite

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed for 2018 using the 2012 definition. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Instructional Objectives

What teachers emphasize in their science instruction heavily influences students' opportunities to learn and is another important factor to consider when examining inequities in science education. The survey provided a list of possible objectives of instruction and asked teachers how much emphasis each would receive in the targeted class. Regardless of school poverty level, classes had relatively equal emphasis on many of these instructional objectives (see Table 2.6). For example, about two-thirds of classes in high-poverty and low-poverty schools heavily emphasized understanding science concepts. Learning how to do science, increasing students' interest in science/engineering, and learning science vocabulary and/or facts were emphasized in approximately 30–40 percent of classes in high-poverty and low-poverty schools. Although not as heavily emphasized as other objectives, learning test-taking strategies were more likely to be emphasized in classes in high-poverty schools than those in low-poverty schools. Looking over time, the 2018 data are not significantly different from the 2012 data.

Table 2.6
Science Classes With Heavy Emphasis on Various Instructional Objectives, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Understanding science concepts	64 (2.2)	60 (2.6)	59 (2.5)	60 (2.5)
Learning how to do science (develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)	40 (2.5)	32 (2.7)	32 (3.0)	33 (2.4)
Learning science vocabulary and/or facts	27 (2.4)	30 (2.8)	30 (2.0)	33 (2.2)
(t) Increasing students' interest in science/engineering	31 (2.3)	27 (2.3)	30 (3.4)	31 (2.4)
Developing students' confidence that they can successfully pursue careers in science/engineering	27 (1.8)	27 (2.4)	27 (3.3)	29 (2.6)
(t) Learning test-taking skills/strategies*	16 (1.6)	20 (1.7)	21 (1.8)	29 (2.1)
(t) Learning about real-life applications of science/engineering	24 (2.1)	22 (1.8)	25 (3.5)	25 (2.5)
Learning about different fields of science/engineering	6 (1.0)	6 (1.2)	10 (3.5)	8 (1.3)
Learning how to do engineering (e.g., identify criteria and constraints, design solutions, optimize solutions)	8 (1.4)	7 (2.2)	9 (3.1)	6 (1.3)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

The objectives related to reform-oriented instruction (understanding science concepts, learning about real-life applications of science/engineering, and increasing students' interest in science/engineering) were combined into a composite variable. The mean scores indicate that science classes were equally likely to emphasize reform-oriented instructional objectives regardless of school poverty level (see Table 2.7). These data are not significantly different from the data in 2012.

Table 2.7
Science Class Mean Scores for the Reform-Oriented Instructional Objectives Composite,[a] by FRL Quartile[(t),†]

	MEAN SCORE
Lowest Quartile Schools	64 (0.8)
Second Quartile Schools	62 (1.0)
Third Quartile Schools	62 (0.8)
Highest Quartile Schools	63 (0.9)

(t) Trend composite

† There is no statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p \geq 0.05$).

a This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed using only the items in common at both time points. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Class Activities

Similar to instructional objectives, the nature of class activities says a great deal about the type of science instruction students receive and their opportunities to learn. The 2018 NSSME+ included several sets of items that provided information about how science was taught. One asked how often different pedagogies were used. As can be seen in Table 2.8, at least 85 percent of classes in both high-FRL and low-FRL schools included explaining science ideas to the whole class and leading whole class discussions at least once a week. Having students work in small groups was also very common regardless of FRL quartile (77–84 percent of classes). However, there were also some differences. Classes in high-FRL schools were more likely than classes in low-FRL to focus on literacy skills (59 vs. 41 percent); write their reflections in class or for homework (45 vs. 36 percent); read from a textbook, module, or other materials in class (43 vs. 30 percent); and practice for standardized tests (29 vs. 11 percent). Flipped instruction, although relatively uncommon across classes, was also more likely to be used in classes in high-FRL schools than classes in low-FRL schools. Conversely, classes in high-FRL schools were less likely than their counterparts in low-FRL schools to do hands on/laboratory activities (51 vs. 68 percent) or engage in project-based learning activities (27 vs. 32 percent). Taken together, these data suggest that classes in high-FRL schools were more likely to use a traditional approach to instruction and less likely to use an investigative approach than their low-FRL counterparts.

Table 2.8
Science Classes in Which Teachers Used Various Activities at Least Once a Week, by FRL Quartile

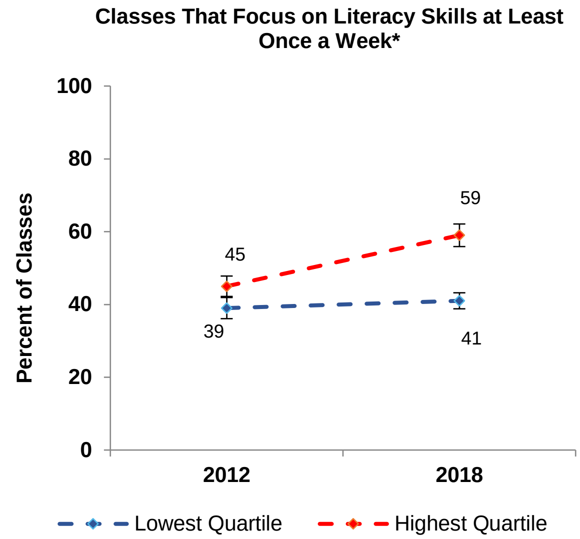
	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Explain science ideas to the whole class	88 (1.5)	90 (1.4)	86 (3.1)	90 (1.4)
(t) Engage the whole class in discussions	85 (1.3)	87 (1.3)	88 (1.3)	86 (1.6)
(t) Have students work in small groups	84 (1.8)	78 (2.4)	77 (1.8)	79 (2.3)
(t) Focus on literacy skills (e.g., informational reading or writing strategies)*	41 (2.2)	47 (2.4)	52 (2.5)	59 (3.1)
(t) Have students do hands-on/laboratory activities*	68 (2.4)	58 (2.8)	58 (2.5)	51 (2.7)
(t) Have students write their reflections (e.g., in their journals, on exit tickets) in class or for homework*	36 (2.3)	35 (2.1)	44 (3.0)	45 (2.1)
(t) Have students read from a textbook, module, or other material in class, either aloud or to themselves*	30 (2.7)	32 (2.3)	33 (2.2)	43 (2.4)
(t) Have students practice for standardized tests*	11 (1.6)	15 (1.7)	19 (2.1)	29 (2.3)
(t) Engage the class in project-based learning (PBL) activities	32 (2.3)	25 (2.1)	30 (3.2)	27 (2.0)
Use flipped instruction (have students watch lectures/demonstrations outside of class to prepare for in-class activities)*	10 (1.3)	9 (1.2)	11 (1.5)	15 (1.8)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

Over time, the difference between the percentages of classes in high-FRL schools and low-FRL schools that focus on literacy skills on a weekly basis has increased (see Figure 2.2). From 2012 to 2018, the percentage of classes in high-FRL schools that focused on literacy skills at least once a week increased substantially while the percentage of classes in low-FRL schools that focused on literacy at least once a week increased only slightly (from 45 to 59 percent and 39 to 41 percent, respectively). Although this increased focus on literacy in high-FRL schools is likely beneficial to students in general, it is not clear the extent to which it facilitates or hinders their learning of science ideas.

**Change Over Time:
Science Class Activities**



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

Figure 2.2

In 2018, teachers were also asked how often they engage students in doing science as described in *A Framework for K–12 Science Education*—i.e., the practices of science such as formulating scientific questions, designing and implementing investigations, developing models and explanations, and engaging in argumentation.[12] Regardless of school poverty level, modest percentages of classes engaged in any of the science practices on a weekly basis (see Table 2.9). For example, just over one-third of classes in high-poverty and low-poverty schools had students: organize and/or represent data using tables, charts or graphs in order to facilitate analysis of the data; make and support claims with evidence; and generate scientific questions at least once a week. Three differences are seen based on poverty level. Classes in high-poverty schools were less likely than classes in low-poverty schools to conduct scientific investigations (36 vs. 47 percent). Conversely, classes in high-poverty schools were more likely than classes in low-poverty schools to evaluate the strengths and weaknesses of competing scientific explanations (21 vs. 14 percent) and determine what details about an investigation might persuade a targeted audience about a scientific claim (17 vs. 12 percent). This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

[12] National Research Council. (2012). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. The National Academies Press. https://doi.org/10.17226/13165.

Table 2.9
Science Classes in Which Students Engaged in Various Aspects of Science Practices at Least Once a Week, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
Organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data	45 (2.2)	43 (2.5)	42 (3.4)	44 (2.3)
Make and support claims with evidence	42 (2.2)	39 (2.4)	38 (2.9)	43 (2.7)
Generate scientific questions	38 (2.3)	38 (2.3)	40 (3.1)	39 (2.8)
Conduct a scientific investigation*	47 (2.7)	41 (2.6)	44 (3.0)	36 (2.4)
Use multiple sources of evidence to develop an explanation	30 (1.7)	28 (2.0)	29 (3.3)	35 (2.6)
Determine what data would need to be collected in order to answer a scientific question	34 (2.3)	34 (2.2)	33 (3.2)	34 (3.1)
Analyze data using grade-appropriate methods in order to identify patterns, trends, or relationships	38 (2.3)	35 (2.0)	36 (3.2)	33 (2.3)
Develop procedures for a scientific investigation to answer a scientific question	32 (1.8)	29 (2.2)	31 (2.8)	31 (2.9)
Determine whether or not a question is scientific	23 (1.8)	22 (2.1)	22 (2.1)	28 (2.4)
Revise their explanations based on additional evidence	25 (2.2)	23 (2.0)	24 (3.0)	27 (2.4)
Compare data from multiple trials or across student groups for consistency in order to identify potential sources of error or inconsistencies in the data	26 (2.2)	24 (1.7)	26 (3.5)	26 (2.5)
Summarize patterns, similarities, and differences in scientific information obtained from multiple sources	21 (1.6)	21 (1.6)	21 (3.4)	26 (2.4)
Develop scientific models—physical, graphical, or mathematical representations of real-world phenomena	25 (1.9)	25 (1.8)	28 (3.0)	25 (2.1)
Use data and reasoning to defend, verbally or in writing, a claim or refute alternative scientific claims	22 (2.1)	21 (1.8)	21 (1.9)	24 (2.2)
Consider how missing data or measurement error can affect the interpretation of data	20 (1.8)	20 (1.9)	13 (1.4)	24 (2.4)
Select and use grade-appropriate mathematical and/or statistical techniques to analyze data	19 (1.6)	20 (1.8)	20 (1.8)	22 (2.0)
Evaluate the strengths and weaknesses of competing scientific explanations*	14 (1.8)	12 (1.4)	14 (1.5)	21 (2.2)
Pose questions that elicit relevant details about the important aspects of a scientific argument	19 (1.8)	17 (1.4)	17 (1.6)	20 (1.9)
Use mathematical and/or computational models to generate data to support a scientific claim	16 (1.6)	17 (1.7)	16 (1.5)	19 (2.0)
Identify the strengths and limitations of a scientific model—in terms of accuracy, clarity, generalizability, accessibility to others, strength of evidence supporting it	16 (1.6)	14 (1.3)	19 (3.3)	17 (1.8)
Evaluate the credibility of scientific information—e.g., its reliability, validity, consistency, logical coherence, lack of bias, or methodological strengths and weaknesses	15 (1.8)	14 (1.3)	12 (1.3)	17 (2.1)
Determine what details about an investigation might persuade a targeted audience about a scientific claim*	12 (1.4)	12 (1.5)	11 (1.5)	17 (1.7)
Construct a persuasive case, verbally or in writing, for the best scientific model or explanation for a real-world phenomenon	13 (1.4)	10 (1.2)	13 (1.6)	15 (1.7)

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

Table 2.10 shows the mean scores for each FRL quartile on the Engaging Students in the Practices of Science Composite formed from these items. Overall, the scores indicate that students across quartiles engaged in the practices of science to a limited extent.

Table 2.10
Science Class Mean Scores for Engaging Students in Practices of Science Composite, by FRL Quartile†

	MEAN SCORE
Lowest Quartile Schools	44 (0.9)
Second Quartile Schools	43 (0.9)
Third Quartile Schools	44 (1.3)
Highest Quartile Schools	45 (1.1)

† There is no statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p \geq 0.05$).

The survey also asked how often students in the randomly selected class were required to take assessments the teacher did not develop, such as state or district benchmark assessments. As can be seen in Table 2.11, students in high-poverty schools were more likely be tested two or more times per year than those in low-poverty schools. This same disparity among high-poverty and low-poverty schools was present in 2012, highlighting a persistent issue in over testing students from groups that have been historically disadvantaged.

Table 2.11
Science Classes Required to Take External Assessments Two or More Times Per Year, by FRL Quartile(t)

	PERCENT OF CLASSES*
Lowest Quartile Schools	20 (2.3)
Second Quartile Schools	32 (3.3)
Third Quartile Schools	36 (3.6)
Highest Quartile Schools	36 (3.1)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

Summary

There are a number of similar aspects of science instruction comparing classes in the highest and lowest FRL quartiles in 2018, but there are also some notable differences. At the elementary level, classes in the highest and lowest quartiles of schools spent approximately the same amount of time on science instruction, though time spent on science was substantially less than that spent on reading/language arts or mathematics. At the high school level, there is a significant difference in the distribution of courses between classes in the highest and lowest FRL quartiles, likely due to the relative abundance of non-college prep courses and lack of advanced science courses in the highest FRL quartile.

Data about teachers' perceptions of control and emphasis on instructional objectives are also mixed. For example, teachers of classes in high-FRL schools felt less control over decisions related to curriculum and pedagogy than teachers of classes in low-FRL schools. However, science classes, regardless of school poverty level, had similar emphasis on reform-oriented instructional objectives (e.g., understanding science concepts, learning how to do science).

The types of instructional activities used in classrooms were relatively similar regardless of school poverty level. The teacher explaining ideas, whole class discussion, and small group work were prominent activities at least once a week in classes in high-poverty schools and low-poverty schools. Also, students in classes in both high-poverty and low-poverty schools had similar, albeit relatively few, opportunities to engage in a number of science practices at least once a week, including organizing and/or representing data using tables, charts, or graphs; making and supporting claims with evidence; and generating scientific questions. However, classes in high-poverty schools were less likely than classes in low-poverty schools to do hands on/laboratory activities or engage in project-based learning activities. Additionally, classes in high-poverty schools were more likely than their counterparts in low-poverty schools to practice for standardized tests and be required to take two or more external assessments per year.

Since 2012, there have been some changes in teachers' perceptions of control over pedagogical decisions (selecting teaching techniques) and curricular decisions (selecting curriculum materials and selecting content, topics, and skills to be taught). In each case, the gap has widened, further disadvantaging classes in high-poverty schools. There is also a notable difference in the extent to which classes in high-poverty schools and low-poverty schools focus on literacy skills on a weekly basis. This gap has widened over time, as high-poverty schools are increasingly likely to focus on literacy during science instruction.

Material Resources

The quality and availability of instructional resources are major factors affecting science teaching and students' opportunities to learn. Therefore, the 2018 NSSME+ included a series of items on instructional materials—which ones teachers use and how they use them—as well as the adequacy of other resources for science instruction. This section provides data about the distribution of material resources and teachers' perceptions of the adequacy of those materials, by FRL quartile.

Instructional Materials

In 2018, a majority of classes, regardless of school poverty level, had district-designated materials for science instruction (see Table 2.12). Commercially published textbooks (69–79 percent of classes) and commercially published kits/modules (46–48 percent of classes) were the most common types of designated materials. Although relatively few classes were designated to use online units or courses that students work through at their own pace, these materials were more likely to be used in classes in high-poverty schools than in classes in low-poverty schools. This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 2.12
Types of Instructional Materials Designated for Science Classes, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
District Designates Instructional Materials*				
No	34 (2.6)	38 (2.8)	37 (3.3)	25 (2.7)
Yes	66 (2.6)	62 (2.8)	63 (3.3)	75 (2.7)
Types of Designated Instructional Materials[a]				
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	69 (4.1)	84 (2.9)	78 (3.3)	79 (3.9)
Commercially published kits/modules (printed or electronic)	46 (3.8)	38 (3.7)	32 (3.4)	48 (3.0)
State, county, district, or diocese-developed units or lessons	36 (2.9)	34 (3.5)	42 (3.3)	36 (3.4)
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)	35 (3.6)	28 (2.6)	38 (3.2)	32 (4.0)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	20 (1.8)	24 (2.2)	23 (2.6)	24 (2.8)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)*	8 (1.7)	8 (1.6)	12 (2.2)	13 (1.8)

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

[a] Only science classes for which instructional materials are designated by the state, district, or diocese are included in these analyses.

Regardless of whether instructional materials had been designated for their class, teachers were asked how often instruction was based on various types of materials. Interestingly, units or lessons created by the teacher were the most commonly used materials, serving as the basis of instruction at least once a week in over half of all classes (see Table 2.13). Commercially published textbooks and units or lessons collected from other sources (e.g., conferences, journals, colleagues) were also quite common across classes, each of which was utilized at least once a week in over one-third of classes. Although less commonly used overall, classes in high-FRL schools were more likely than classes in low-FRL schools to use lessons or resources from websites that have a subscription fee or per lesson cost (39 vs. 29 percent), lessons or resources from websites that are free (32 vs. 21 percent), and online units or courses that students work through at their own pace (10 vs. 6 percent). This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 2.13
Science Classes Basing Instruction on Various Types of Instructional Materials at Least Once a Week, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
Units or lessons you created (either by yourself or with others)	67 (2.8)	66 (2.5)	64 (2.5)	58 (3.4)
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	42 (2.6)	43 (2.7)	40 (2.9)	46 (2.7)
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)*	29 (2.7)	37 (2.8)	43 (3.0)	39 (3.4)
Units or lessons you collected from any other source (e.g., conferences, journals, colleagues, university or museum partners)	37 (2.5)	38 (2.3)	37 (2.8)	36 (2.7)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)*	21 (1.7)	26 (1.7)	28 (2.8)	32 (2.9)
Commercially published kits/modules (printed or electronic)	30 (2.5)	20 (1.8)	20 (2.2)	29 (2.6)
State, county, district, or diocese-developed units or lessons	24 (2.1)	21 (2.1)	27 (3.6)	27 (2.5)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)*	6 (1.1)	7 (1.1)	9 (1.4)	10 (1.5)

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

Teachers who used commercially published textbooks were asked to record the title, author, year, and ISBN of the textbook used most often in the class. As can be seen in Table 2.14, more than two-thirds of classes, regardless of FRL quartile, used textbooks that were six or more years old.

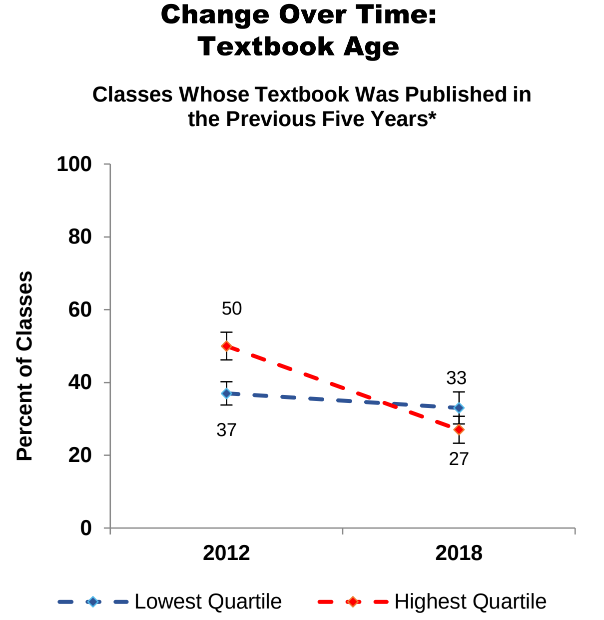
Table 2.14
Age of Science Textbooks in 2018, by FRL Quartile[(t),†]

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
6 or more years old	67 (4.4)	74 (3.9)	74 (4.3)	73 (3.7)
5 or fewer years old	33 (4.4)	26 (3.9)	26 (4.3)	27 (3.7)

(t) Trend item

† There is no statistically significant difference in the distribution between classes in the lowest quartile of schools and those in the highest quartile of schools (Chi-square test of independence, $p \geq 0.05$).

Interestingly, in 2012, there was a large difference in the percentage of classes in high-FRL schools and those in low-FRL schools whose textbook was published in the previous five years, with high-FRL schools being more likely to have newer textbooks. However, this difference has decreased since 2012; a trend that negatively impacts classes in high-poverty schools (see Figure 2.3). In 2012, 50 percent of classes in high-FRL schools used a textbook that was published in the previous five years, compared to only 27 percent of classes in 2018. In contrast, the extent to which classes in low-FRL schools used textbooks published in the previous five years changed very little from 2012 to 2018 (37 vs. 33 percent).



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

Figure 2.3

Facilities and Equipment

Access to adequate facilities and equipment is another important component of students' opportunity to learn. Given the increased emphasis on computing in instruction across STEM disciplines, the 2018 NSSME+ included several questions about availability of computing resources. As can be seen in Table 2.15, the highest and lowest quartiles of schools had similar access to each type of resource. Virtually all schools had school-wide Wi-Fi and a large majority had laptop/tablet carts and access to computer labs. However, only a third of schools had a 1-to-1 initiative where every student was provided with a laptop or tablet. Looking over time, the 2018 data are not significantly different from the 2012 data.

Table 2.15
Schools With Various Computing Resources, by FRL Quartile†

	PERCENT OF SCHOOLS			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
School-wide Wi-Fi	99 (0.7)	97 (1.5)	100 (0.2)	98 (1.2)
(t) Laptop/tablet carts available for teachers to use with their classes	83 (2.9)	86 (3.0)	85 (2.8)	88 (2.2)
(t) One or more computer labs available for teachers to schedule for their classes	66 (4.4)	79 (3.0)	67 (4.1)	71 (4.1)
A 1-to-1 initiative (every student is provided with a laptop or tablet)	34 (3.3)	40 (4.3)	44 (4.0)	33 (4.1)

† There are no statistically significant differences between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p \geq 0.05$).

The survey also asked about classroom availability of instructional resources. As can be seen in Table 2.16, nearly all classes, regardless of poverty level, had access to projection devices. Large percentages of classes also had access to balances; however, this resource was less likely to be available in high-poverty schools than low-poverty schools (81 vs. 91 percent). Similarly, probes for collecting data were less likely to be available in classes in high-poverty schools than low-poverty schools (49 vs. 64 percent). The differences in the availability of these technologies according to school poverty level have not changed significantly since 2012.

Table 2.16
Availability[a] of Instructional Resources in Science Classes, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
Projection devices (e.g., Smartboard, document camera, LCD projector)	97 (1.4)	99 (0.4)	99 (0.6)	97 (1.2)
Balances (e.g., pan, triple beam, digital scale)*	91 (2.0)	91 (1.7)	89 (2.1)	81 (2.5)
(t) Microscopes	75 (2.6)	77 (2.9)	74 (3.2)	68 (3.5)
(t) Probes for collecting data (e.g., motion sensors, temperature probes)*	64 (3.4)	57 (3.5)	55 (3.6)	49 (3.0)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes only those teachers indicating the resource is always available in their classroom or available upon request.

Additionally, teachers were asked about the availability of laboratory facilities for science instruction (see Table 2.17). Electric outlets and faucets and sinks were both widely available regardless of poverty level. Gas for burners and fume hoods were also quite common at the high school level, but less so in classes in the highest FRL quartile than those in the lowest FRL quartile (73 vs. 91 percent and 48 vs. 55 percent, respectively). The 2018 data are not significantly different from the 2012 data.

Table 2.17
Availability[a] of Laboratory Facilities in Science Classes, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Electric outlets	96 (1.1)	96 (1.1)	97 (1.1)	92 (1.8)
(t) Faucets and sinks	88 (2.9)	90 (1.8)	88 (2.1)	85 (2.1)
(t) Gas for burners*,[b]	91 (2.4)	93 (2.2)	84 (3.6)	73 (5.2)
(t) Fume hoods*,[b]	87 (2.9)	87 (2.6)	80 (4.2)	71 (5.9)
(t) Lab tables	55 (3.7)	64 (4.1)	59 (3.9)	48 (3.7)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes those science teachers indicating the resource is either located in the classroom or available in another room.

[b] These items were only asked if the teacher indicated that they teach a high school-level course.

The 2018 NSSME+ also collected information about school spending during the most recently completed school year on science equipment, consumable supplies, and software. By dividing these amounts by school enrollment, per-pupil estimates were generated. As can be seen in Table 2.18, expenditures for science were not distributed equally across schools. High-FRL schools spent considerably less per pupil on science resources than low-FRL schools ($2.05 per pupil vs. $5.62 per pupil). Adjusting for inflation, the 2018 data on spending are not significantly different from the 2012 data.

Table 2.18
Median School Spending Per Pupil on Science Equipment, Consumable Supplies, and Software, by FRL Quartile(t)

	MEDIAN AMOUNT*
Lowest Quartile Schools	$5.62 (0.8)
Second Quartile Schools	$3.44 (0.7)
Third Quartile Schools	$2.55 (0.6)
Highest Quartile Schools	$2.05 (0.7)

(t) Trend item

* There is a statistically significant difference between schools in the lowest quartile and those in the highest quartile (Mood's median test, $p < 0.05$).

Teachers were asked about the adequacy of instructional resources they have available. Across all categories (instructional technology, equipment, facilities, consumable supplies), teachers of classes in high-FRL schools were less likely than their counterparts in low-FRL schools to rate their resources as adequate (see Table 2.19). The same inequities between schools were present in 2012.

Table 2.19
Adequacy[a] of Resources for Science Instruction, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Instructional technology (e.g., calculators, computers, probes/sensors)*	62 (3.6)	59 (3.2)	58 (3.8)	46 (3.2)
(t) Equipment (e.g., thermometers, magnifying glasses, microscopes, beakers, photogate timers, Bunsen burners)*	58 (3.2)	57 (3.1)	50 (4.2)	44 (2.7)
(t) Facilities (e.g., lab tables, electric outlets, faucets and sinks)*	57 (3.4)	58 (3.1)	52 (4.0)	42 (3.2)
(t) Consumable supplies (e.g., chemicals, living organisms, batteries)*	56 (3.4)	42 (3.0)	42 (4.1)	30 (2.8)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

a Includes science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not adequate" to 5 "adequate."

These items were combined into a composite variable called Adequacy of Resources for Science Instruction. As shown in Table 2.20, teachers of classes in high-poverty schools had less positive views about their resources compared to those in low-poverty schools (mean scores of 54 vs. 66). The 2018 data are not significantly different from the 2012 data.

Table 2.20
Science Class Mean Scores for the Adequacy of Resources for Instruction Composite, by FRL Quartile(t)

	MEAN SCORE*
Lowest Quartile Schools	66 (2.1)
Second Quartile Schools	63 (2.0)
Third Quartile Schools	61 (2.8)
Highest Quartile Schools	54 (1.6)

(t) Trend composite

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

Summary

Overall, findings about the distribution of material resources for science instruction between high-poverty and low-poverty schools are mixed. The majority of classes had district-designated materials for science instruction, most commonly commercially published textbooks. However, regardless of whether instructional materials had been designated for their class, teachers in high-poverty and low-poverty schools most frequently used units or lessons they created as the basis of their science instruction.

Computing resources, including school-wide Wi-Fi and laptop/tablet carts, were equally available to students in both high-FRL schools and low-FRL schools. Several instructional resources (e.g., projection devices and microscopes) and laboratory facilities (e.g., faucets and sinks, lab tables) were also available to a similar extent in classes in high-FRL and low FRL-schools. However, there were also differences in the availability of these resources that disadvantaged classes in high-FRL schools, including less access to microscopes, probes for collecting data, gas for burners, and fume hoods. Further, the amount of money spent per pupil on science equipment, consumable supplies, and software in high-FRL schools was considerably less than the amount in low-FRL schools.

These disparities translated into teachers' perceptions of the adequacy of resources for science instruction. Teachers of classes in high-FRL schools had less-positive views about the resources available to them than those in classes of low-FRL schools.

Because many survey items related to material resources were added, removed, or substantially modified between 2012 and 2018, trend analysis was limited. However, it is noteworthy that, in 2012, there was a large gap between the percentages of classes in high-FRL schools and those in low-FRL schools whose textbook was published in the previous five years, with high-FRL schools being more likely to have newer textbooks. However, this pattern changed over time. Many fewer classes in high-FRL schools had newer textbooks in 2018 than in 2012, with little corresponding change in low-FRL schools.

Well-Prepared Teachers

Of all the resources that factor into students' science education experience and their opportunity to learn, teachers are among the most important. The 2018 NSSME+ collected data on a number of indicators of teacher preparedness, including their years of teaching experience, content preparation, beliefs about teaching and learning, perceptions of preparedness to teach science content and use classroom pedagogies, and professional development experiences. The distribution of well-prepared teachers among schools in different FRL quartiles is described in the following sections.

Teacher Characteristics and Preparation

Table 2.21 shows data about the characteristics and preparation of science teachers. About three-fourths of classes at the elementary and middle grades levels, regardless of poverty level, were taught by teachers who had completed the majority of National Science Teachers Association (NSTA) recommended courses (chemistry, Earth science, and life science at all grades with the addition of physics at the middle grades).[13] Similarly, three-fourths of classes at the secondary level, regardless of poverty level, were taught by teachers with a degree in science or science education. However, there were also some differences in teacher characteristics and preparation by school FRL status. Classes in the highest quartile of schools were more likely than classes in the lowest quartile of schools to be taught by teachers from historically underrepresented race/ethnicity groups (33 vs. 8 percent), a positive finding that suggests students of color (who are frequently represented in high-FRL schools) have opportunities to see teachers who look like them represented in the teaching force. However, classes in the highest quartile of schools were also more likely to be taught by teachers with 0–5 years of science teaching experience (38 vs. 27 percent). Further, at the secondary level, classes in the highest quartile of schools were less likely to be taught by teachers with a degree or 3+ advanced courses in the subject of the class (e.g., biology, chemistry, physics) than classes in the lowest quartile (52 vs. 66 percent).

Table 2.21
Teacher Characteristics, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Teacher completed all or all-but-one of the NSTA recommended courses[a]	71 (3.1)	72 (2.6)	71 (3.3)	78 (2.1)
(t) Secondary teacher with a degree in science or science education	79 (2.7)	78 (2.9)	75 (3.5)	76 (3.6)
(t) Secondary teacher with a degree or 3+ advanced courses in the subject*	66 (2.7)	64 (3.1)	62 (3.6)	52 (4.2)
(t) 0–5 years of experience teaching science*	27 (2.2)	26 (2.1)	42 (3.5)	38 (2.6)
(t) Historically underrepresented race/ethnicity group*	8 (1.3)	11 (2.5)	13 (2.1)	33 (2.9)
Full-time job experience in science or engineering prior to teaching	18 (2.3)	14 (1.9)	15 (2.0)	19 (2.3)

(t) Trend item

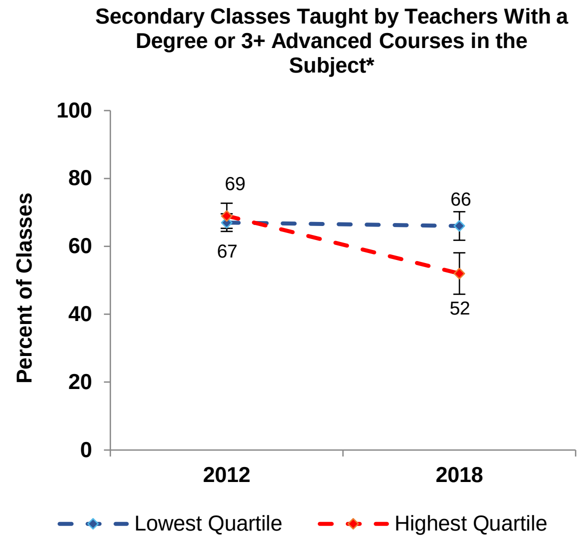
* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

[a] NSTA only has recommended courses for elementary and middle school grades teachers; high school teachers are not included.

As can be seen in Figure 2.4, the difference between the percentages of classes in high-FRL schools and low-FRL schools taught by teachers with a degree or 3+ advanced courses in the subject of the class has changed significantly from 2012. The widening of the gap appears to be due to fewer classes in the highest FRL quartile being taught by teachers with in-depth course background in 2018 than in 2012 (52 vs. 69 percent).

[13] National Science Teachers Association. (2012). *NSTA science content analysis form: Elementary science specialist or middle school science teachers.* Arlington, VA: Author.

Change Over Time:
Teacher Characteristics



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

Figure 2.4

Teacher Pedagogical Beliefs

Because beliefs are important mediators of behaviors, teachers were asked about their beliefs regarding effective teaching and learning. As can be seen in Table 2.22, teachers tended to hold a number of reform-oriented beliefs, regardless of school poverty level. For example, over 90 percent of classes in high-FRL and low-FRL schools were taught by teachers who agreed that: (1) they should ask students to support their conclusions about a science concept with evidence, (2) students learn best when instruction is connected to their everyday lives, (3) students should learn science by doing science, (4) most class periods should provide opportunities for students to share their thinking and reasoning, and (5) most class periods should provide opportunities for students to apply scientific ideas to real-world contexts.

Although teachers in general appeared to hold fewer traditional beliefs, classes in high-FRL schools were more likely than those in low-FRL schools to be taught by teachers who agreed with statements associated with traditional beliefs. For instance, teachers of classes in high-FRL schools were more likely than those of classes in low-FRL schools to believe that: (1) at the beginning of instruction on a science idea, students should be provided with definitions for new scientific vocabulary that will be used (81 vs. 65 percent); (2) hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned (63 vs. 49 percent); and (3) teachers should explain an idea to students before having them consider evidence that relates to the idea (37 vs. 27 percent). The 2018 data are not significantly different from the 2012 data.

Table 2.22
Science Classes in Which Teachers Agreed[a] With Various Statements About Teaching and Learning, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
Reform-Oriented Beliefs				
Students learn best when instruction is connected to their everyday lives.	96 (1.1)	97 (0.8)	95 (1.2)	97 (0.9)
Students should learn science by doing science (e.g., developing scientific questions; designing and conducting investigations; analyzing data; developing models, explanations, and scientific arguments).	94 (1.1)	94 (1.7)	96 (1.0)	95 (1.2)
(t) Most class periods should provide opportunities for students to share their thinking and reasoning.	93 (1.2)	95 (1.6)	93 (1.2)	95 (1.2)
Teachers should ask students to support their conclusions about a science concept with evidence.	98 (0.8)	98 (0.6)	95 (1.0)	94 (1.9)
Most class periods should provide opportunities for students to apply scientific ideas to real-world contexts.	92 (1.4)	93 (1.9)	92 (1.4)	94 (1.4)
(t) It is better for science instruction to focus on ideas in depth, even if that means covering fewer topics.	77 (2.4)	74 (2.6)	78 (2.7)	73 (2.4)
Traditional Beliefs				
(t) At the beginning of instruction on a science idea, students should be provided with definitions for new scientific vocabulary that will be used.*	65 (2.9)	71 (2.5)	68 (4.2)	81 (2.1)
(t) Hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned.*	49 (2.8)	50 (2.7)	54 (3.5)	63 (2.9)
(t) Students learn science best in classes with students of similar abilities.	39 (2.6)	40 (3.2)	38 (3.2)	42 (3.0)
(t) Teachers should explain an idea to students before having them consider evidence that relates to the idea.*	27 (2.7)	32 (3.3)	35 (3.3)	37 (2.6)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes teachers indicating "strongly agree" or "agree" on a five-point scale ranging from 1 "strongly disagree" to 5 "strongly agree."

These items were combined into two composite variables: Reform-Oriented Teaching Beliefs and Traditional Teaching Beliefs. As can be seen in Table 2.23, there are no differences in reform-oriented beliefs between teachers of classes in the highest and lowest quartiles of schools. However, teachers of classes in the highest quartile held more traditional beliefs than those in the lowest quartile (composite mean scores of 60 vs. 54). The 2018 data for the Traditional Teaching Beliefs composite are not significantly different from the 2012 data.[14]

[14] Too few of the items in the 2018 Reform-Oriented Beliefs composite were also asked in 2012 to allow for a comparable composite to be created to examine trends over time.

Table 2.23
Science Class Mean Scores for Teachers' Beliefs About Teaching and Learning Composites, by FRL Quartile

	MEAN SCORE			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
Reform-Oriented Teaching Beliefs	87 (0.7)	86 (0.8)	87 (0.7)	86 (0.7)
(t) Traditional Teaching Beliefs*,[a]	54 (1.1)	56 (1.1)	56 (2.4)	60 (0.9)

(t) Trend composite

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was not originally computed for the 2012 study. To allow for comparisons across time, it was computed for 2012 using the 2018 definition.

Teachers' Perceptions of Preparedness

The survey asked teachers how well prepared they felt to teach each of a number of science topics at their assigned grade level. At the elementary level, teachers of classes in the highest and lowest quartiles of schools felt equally well prepared to teach life science, Earth/space science, and physical science (see Table 2.24). However, it is worth noting that fewer than one-third felt very well prepared in any of these areas. Engineering stands out as a topic that very few elementary teachers felt very well prepared to teach. Further, fewer classes in high-FRL schools were taught by teachers who felt very well prepared to teach engineering than classes in low-FRL schools (1 vs. 8 percent). The 2018 data are not significantly different from the 2012 data.

Table 2.24
Elementary Classes in Which Teachers Considered Themselves Very Well Prepared to Teach Various Science Topics, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Life Science	29 (3.9)	24 (3.2)	25 (3.7)	26 (4.0)
(t) Earth/space Science	24 (4.0)	18 (2.6)	22 (3.7)	20 (3.0)
(t) Physical Science	16 (3.3)	13 (2.3)	20 (5.5)	14 (3.6)
(t) Engineering*	8 (2.7)	3 (1.6)	8 (6.1)	1 (0.5)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

At the secondary level, there were no differences between the highest and lowest quartiles in the percentages of classes taught by teachers considering themselves very well prepared to teach the topics related to their randomly selected class (see Table 2.25). The 2018 data are not significantly different from the 2012 data.

Table 2.25
Secondary Science Classes in Which Teachers[a] Considered Themselves Very Well Prepared to Teach Each of a Number of Topics, by FRL Quartile[†]

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
Earth/Space Science				
(t) Earth's features and physical processes	52 (5.0)	53 (6.3)	41 (4.5)	46 (5.8)
(t) The solar system and the universe	42 (4.3)	40 (4.8)	33 (3.8)	42 (5.5)
(t) Climate and weather	41 (4.7)	39 (5.3)	30 (4.3)	32 (4.8)
Biology/Life Science				
(t) Structures and functions of organisms	68 (4.0)	64 (3.6)	63 (3.7)	61 (4.5)
(t) Ecology/ecosystems	61 (4.0)	61 (3.5)	58 (3.7)	61 (4.1)
(t) Cell biology	64 (3.6)	62 (3.4)	64 (3.9)	59 (4.2)
(t) Genetics	60 (4.0)	61 (4.0)	57 (3.6)	51 (4.5)
(t) Evolution	54 (3.3)	51 (3.9)	51 (3.8)	47 (4.3)
Chemistry				
(t) Atomic structure	70 (3.8)	67 (4.0)	55 (4.1)	66 (4.5)
(t) States, classes, and properties of matter	74 (3.5)	73 (4.0)	61 (4.1)	65 (5.1)
(t) Elements, compounds, and mixtures	67 (3.9)	72 (4.1)	57 (4.6)	61 (5.3)
(t) The periodic table	66 (3.8)	72 (4.2)	56 (4.3)	61 (5.4)
(t) Chemical bonding, equations, nomenclature, and reactions	49 (3.5)	59 (3.8)	42 (4.0)	49 (4.8)
(t) Properties of solutions	54 (3.9)	51 (3.9)	41 (3.5)	44 (4.5)
Physics				
(t) Forces and motion	56 (4.1)	57 (3.7)	44 (3.6)	57 (4.1)
(t) Energy transfers, transformations, and conservation	50 (3.7)	57 (3.4)	45 (3.7)	54 (4.8)
(t) Properties and behaviors of waves	37 (3.2)	37 (3.7)	23 (2.9)	32 (4.3)
(t) Electricity and magnetism	29 (3.2)	30 (3.8)	23 (3.2)	31 (4.2)
(t) Modern physics	13 (2.6)	10 (2.3)	9 (2.0)	14 (3.3)
(t) **Environmental and Resource Issues** (e.g., land and water use, energy resources and consumption, sources and impacts of pollution)	40 (5.0)	39 (4.6)	45 (5.5)	40 (5.4)

(t) Trend item

† There are no statistically significant differences between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p \geq 0.05$).

a Each secondary science teacher was asked about one set of science topics based on the discipline of his/her randomly selected class.

Consistent with teachers' perceptions of preparedness to teach engineering at the elementary level, few science classes at the secondary level were taught by teachers who considered themselves very well prepared to teach various engineering topics (see Table 2.26). However, teachers of classes in the highest quartile of schools were less likely than their counterparts in the lowest quartile to feel well prepared to teach about optimizing design solutions (5 vs. 9 percent). This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 2.26
Secondary Science Classes in Which Teachers Considered Themselves Very Well Prepared to Teach Each of a Number of Engineering Topics, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
Developing possible solutions	11 (1.4)	12 (1.7)	8 (1.4)	9 (2.2)
Defining engineering problems	10 (1.4)	10 (1.4)	7 (1.4)	7 (1.2)
Optimizing design solutions*	9 (1.3)	9 (1.4)	5 (1.2)	5 (1.1)

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

The survey asked teachers two series of items focused on their preparedness for a number of tasks associated with instruction. First, they were asked how well prepared they felt to use a number of student-centered pedagogies, including encouraging participation of all students and differentiating instruction to meet learners' needs. Second, they were asked how well prepared they felt to carry out a number of tasks related to monitoring and addressing student thinking in their most recent unit.

As can be seen in Table 2.27, classes in high-poverty and low-poverty schools were equally likely to be taught by teachers who felt very well prepared to use formative assessment to monitor student learning, encourage students' interest in science and/or engineering, differentiate science instruction, provide science instruction based on student's ideas, and develop students' awareness of STEM careers. However, differences by poverty level are also evident. Teachers of classes in high-poverty schools were less well prepared than their counterparts in low-poverty schools to develop students' conceptual understanding (34 vs. 44 percent), encourage participation of all students in science and/or engineering (33 vs. 41 percent), and develop students' abilities to do science (27 vs. 35 percent). Conversely, teachers of classes in high-poverty schools felt better prepared than teachers of classes of low-poverty schools to incorporate students' cultural backgrounds into science instruction (21 vs. 10 percent). For the one trend item, there is no significant difference over time.

Table 2.27
Science Classes in Which Teachers Considered Themselves Very Well Prepared for Each of a Number of Tasks, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
Use formative assessment to monitor student learning	42 (2.3)	42 (2.4)	41 (2.9)	37 (2.6)
Develop students' conceptual understanding*	44 (2.6)	38 (2.2)	34 (2.2)	35 (2.9)
Encourage participation of all students in science and/or engineering*	41 (2.3)	41 (2.4)	36 (2.9)	33 (2.3)
(t) Encourage students' interest in science and/or engineering	39 (2.1)	39 (2.3)	33 (3.0)	33 (2.1)
Differentiate science instruction to meet the needs of diverse learners	24 (1.8)	29 (2.0)	29 (3.0)	28 (2.0)
Develop students' abilities to do science (e.g., develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)*	35 (2.4)	33 (2.4)	27 (1.9)	27 (2.3)
Incorporate students' cultural backgrounds into science instruction*	10 (1.2)	15 (1.5)	14 (1.5)	21 (1.9)
Provide science instruction that is based on students' ideas	17 (1.9)	19 (1.6)	20 (3.0)	19 (2.4)
Develop students' awareness of STEM careers	14 (1.4)	18 (1.7)	15 (2.9)	14 (1.3)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

Table 2.28 shows the percentage of science classes taught by teachers who felt very well prepared for each of a number of tasks related to instruction within a particular unit in a designated class. Teachers in more than one-third of classes felt very well prepared to monitor student understanding during the unit, regardless of quartile. Additionally, teachers in more than one-quarter of classes felt very well prepared to find out what students thought or already knew about the key science ideas in the unit. However, teachers of classes in the highest quartile of schools perceived themselves as less well prepared than teachers in the lowest quartile of schools to assess student understanding at the conclusion of the unit (38 vs. 49 percent), implement the instructional materials to be used during the unit (36 vs. 46 percent), and anticipate difficulties that students may have with particular science ideas and procedures in the unit (27 vs. 37 percent). Looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 2.28
Science Classes in Which Teachers Felt Very Well Prepared for Various Tasks in the Most Recent Unit, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Assess student understanding at the conclusion of this unit*	49 (2.3)	49 (2.6)	43 (2.5)	38 (2.6)
(t) Monitor student understanding during this unit	44 (2.3)	44 (2.5)	42 (2.8)	38 (2.7)
(t) Implement the instructional materials to be used during this unit*	46 (2.5)	42 (2.3)	35 (2.8)	36 (2.6)
(t) Find out what students thought or already knew about the key science ideas	36 (2.0)	36 (2.0)	36 (3.4)	31 (2.5)
(t) Anticipate difficulties that students may have with particular science ideas and procedures in this unit*	37 (2.2)	35 (2.1)	27 (2.3)	27 (2.4)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

The preparedness items were used to create four composite variables: Perceptions of Science Content Preparedness, Perceptions of Engineering Content Preparedness, Perceptions of Pedagogical Preparedness, and Preparedness to Implement Instruction in a Particular Unit. As can be seen in Table 2.29, there were no differences between classes in high-FRL schools and classes in low-FRL schools in terms of teacher engineering content preparedness or pedagogical preparedness. However, classes in high-FRL schools were less likely than classes in low-FRL schools to be taught by teachers who had strong feelings of science content preparedness (mean scores of 62 vs. 68) or preparedness to implement instruction in a particular unit (mean scores of 71 vs. 76). The 2018 data for the Science Content Preparedness and Preparedness to Implement Instruction in a Particular Unit composites are not significantly different from the 2012 data.[15]

Table 2.29
Science Class Mean Scores for Teachers' Perceptions of Preparedness Composites, by FRL Quartile

	MEAN SCORE			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Perceptions of Content Preparedness*,[a]	68 (1.6)	65 (1.5)	63 (1.5)	62 (1.5)
Perceptions of Preparedness to Teach Engineering	37 (1.5)	39 (1.4)	35 (1.6)	37 (2.1)
Perceptions of Pedagogical Preparedness	64 (1.0)	65 (1.1)	63 (1.3)	63 (1.4)
(t) Perceptions of Preparedness to Implement Instruction in Particular Unit*	76 (0.9)	75 (0.9)	73 (1.1)	71 (1.4)

(t) Trend composite

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed for 2018 using the 2012 definition. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

[15] Too few of the items in the 2018 version of the Pedagogical Preparedness composite were also asked in 2012 to allow for a comparable composite to be created to examine trends over time. The Engineering Content Preparedness composite is new to the 2018 NSSME+, thus, trend data are not available to report.

Teacher Professional Development

Another important indicator of teacher preparation is participation in professional development. Science teachers, like all professionals, need opportunities to keep up with advances in their field, including disciplinary content and means of helping their students learn important science/engineering concepts. The 2018 NSSME+ collected data on teachers' participation in professional development, including duration and characteristics of the experiences.

Interestingly, regardless of school poverty level, nearly three-quarters of classes were taught by teachers who participated in science-focused professional development in the previous three years (see Table 2.30). However, fewer than one-fifth of classes were taught by teachers who had more than 35 hours of professional development within that timeframe. The 2018 data are not significantly different from the data in 2012.

Table 2.30
Professional Development Experiences of Teachers of Science Classes, by FRL Quartile†

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Teacher has had PD in the previous three years	73 (2.5)	69 (2.5)	73 (2.6)	71 (3.0)
(t) Teacher has had more than 35 hours of PD in the previous three years	20 (1.6)	20 (2.1)	16 (1.7)	18 (1.8)

(t) Trend item

† There are no statistically significant differences between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p \geq 0.05$).

The effectiveness and impacts of professional development depend on how the time is spent—that is, how the experience is structured and facilitated to provide teachers with meaningful learning opportunities. It is widely agreed upon that teachers need opportunities to work with colleagues who face similar challenges, including other teachers from their school and those who have similar teaching assignments. Other recommendations include providing opportunities for teachers to engage in investigations (to learn disciplinary content and to experience inquiry-oriented learning), examine student work and other classroom artifacts for evidence of what students do and do not understand, and apply what they have learned in their classrooms and subsequently discuss how it went.[16] Accordingly, teachers who had participated in professional development in the previous three years were asked a series of additional questions about the nature of those experiences.

As can be seen in Table 2.31, teachers of classes in both the highest quartile and lowest quartile of schools who had participated in professional development had similar experiences. For example, over half of classes in both quartiles were taught by teachers who worked closely with other teachers from their schools, or with other teachers who taught the same grade and/or subject

[16] Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*(3), 181–199.

Elmore, R. F. (2002). *Bridging the gap between standards and achievement: The imperative for professional development in education.* Albert Shanker Institute.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915–945.

whether or not they were from their schools. Other relatively common experiences for teachers in both quartiles included experiencing lessons as their students would from the textbooks/units they use and engaging in science investigations/engineering design challenges. The 2018 data are not significantly different from the 2012 data.

Table 2.31
Science Classes in Which Teachers' Professional Development in the Previous Three Years Had Each of a Number of Characteristics to a Substantial Extent,[a] by FRL Quartile[†]

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Worked closely with other teachers from their school	60 (3.4)	56 (3.1)	55 (3.3)	60 (3.9)
(t) Worked closely with other teachers who taught the same grade and/or subject whether or not they were from their school	54 (2.8)	51 (3.2)	48 (3.5)	53 (4.0)
Had opportunities to experience lessons, as their students would, from the textbook/modules they use in their classroom	42 (3.4)	36 (3.4)	48 (3.0)	45 (3.9)
(t) Had opportunities to engage in science investigations/engineering design challenges	41 (3.2)	45 (3.8)	38 (3.2)	44 (3.8)
(t) Had opportunities to apply what they learned to their classroom and then come back and talk about it as part of the professional development	37 (2.7)	38 (3.7)	32 (2.9)	39 (3.6)
(t) Had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction)	38 (2.9)	32 (3.4)	35 (3.0)	33 (3.7)
Had opportunities to rehearse instructional practices during the professional development (i.e., try out, receive feedback, and reflect on those practices)	25 (2.6)	25 (3.2)	31 (3.0)	32 (3.2)

(t) Trend item

† There are no statistically significant differences between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p \geq 0.05$).

a Includes science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent."

The focus of professional development opportunities is another important factor in assessing teacher preparation. As can be seen in Table 2.32, teachers who had participated in professional development pointed to a number of similarities in the emphases of their professional development experiences, regardless of FRL quartile. For example, teachers in roughly 40–50 percent of classes had professional development opportunities that heavily emphasized deepening their understanding of how science is done, monitoring student understanding, deepening their own science content knowledge, monitoring student understanding during science instruction, and differentiating science instruction to meet the needs of diverse learners. There was only one difference in professional development emphasis between the highest and lowest quartiles of schools. Classes in high-FRL schools were more likely than those in low-FRL schools to be taught by teachers whose professional development heavily emphasized incorporating students' cultural backgrounds into science instruction (32 vs. 17 percent). Although all teachers could benefit from guidance on how to incorporate students' cultural backgrounds into instruction, it appears as though this topic is more likely to be addressed in schools with diverse student populations. When looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 2.32

Science Classes Taught by Teachers Whose Professional Development in the Previous Three Years Gave Heavy Emphasis[a] to Various Areas, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
Deepening their understanding of how science is done (e.g., developing scientific questions, developing and using models, engaging in argumentation)	50 (3.4)	45 (3.2)	50 (3.4)	51 (3.9)
(t) Deepening their own science content knowledge	42 (3.1)	42 (3.4)	46 (2.8)	49 (4.1)
(t) Monitoring student understanding during science instruction	45 (3.0)	46 (3.6)	41 (3.5)	48 (4.6)
Differentiating science instruction to meet the needs of diverse learners	40 (3.2)	44 (3.5)	42 (2.8)	45 (4.7)
(t) Learning about difficulties that students may have with particular science ideas	31 (3.8)	32 (2.8)	30 (3.2)	40 (4.3)
(t) Finding out what students think or already know prior to instruction on a topic	34 (3.4)	38 (2.8)	37 (3.2)	39 (4.0)
Learning how to provide science instruction that integrates engineering, mathematics, and/or computer science	40 (3.5)	42 (3.8)	34 (3.4)	35 (4.1)
(t) Implementing the science textbook/modules to be used in their classroom	28 (2.9)	34 (3.0)	29 (2.8)	34 (3.8)
Incorporating students' cultural backgrounds into science instruction*	17 (2.5)	23 (2.4)	22 (2.9)	32 (4.0)
Deepening their understanding of how engineering is done (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)	27 (3.2)	29 (3.2)	22 (2.5)	24 (2.9)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent."

Survey items describing the characteristics and focus of teachers' professional development were combined into two composite variables: Extent Professional Development Aligns with Elements of Effective Professional Development and Extent Professional Development Supports Student-Centered Instruction. As can be seen in Table 2.33, there are no significant differences between classes in the lowest and highest quartiles of schools in either of these areas. However, class mean scores of approximately 50 indicate that teachers' professional development opportunities were only somewhat aligned with elements of effective professional development and somewhat supportive of student-centered instruction. Looking over time, the 2018 Extent Professional Development Aligns with Elements of Effective Professional Development composite mean score is not significantly different from the 2012 score.[17]

[17] Too few of the items in the 2018 version of the Extent Professional Development Supports Student-Centered Instruction composite were also asked in 2012 to allow for a comparable composite to be created to examine trends over time.

Table 2.33
Science Class Mean Scores for Teachers' Professional Development Composites, by FRL Quartile†

	MEAN SCORE			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Extent Professional Development Aligns With Elements of Effective Professional Development[a]	53 (1.4)	52 (1.5)	52 (1.4)	54 (1.5)
Extent Professional Development Supports Student-Centered Instruction	51 (1.5)	52 (1.3)	50 (1.5)	53 (2.0)

(t) Trend composite

† There are no statistically significant differences between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p \geq 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed using only the items in common at both time points. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Summary

Although there are many similarities in the distribution of well-prepared teachers between high-FRL and low-FRL schools in 2018, there are also several notable differences. Most classes in high-FRL and low-FRL schools were taught by teachers who had completed the majority of NSTA recommended courses (elementary and middle grades levels) and/or had a degree in science or science education (high school level). Encouragingly, classes in high-FRL schools were more likely than classes in low-FRL schools to be taught by a teacher from a race/ethnicity group historically underrepresented in STEM. However, classes in high-FRL schools were also more likely to be taught by teachers with 0–5 years of science teaching experience.

Looking at teacher pedagogical beliefs, there were no differences in reform-oriented beliefs between teachers of classes in the highest and lowest quartiles of schools. However, teachers of classes in the highest quartile held more traditional beliefs than to those in the lowest quartile. For example, classes in the highest quartile were more likely than classes in the lowest quartile to be taught by teachers who agreed that students should be provided with definitions for new scientific vocabulary at the beginning of instruction on a science idea, hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned, and teachers should explain an idea to students before having them consider evidence that relates to the idea.

Teachers of classes in the highest and lowest FRL quartiles felt equally well prepared to teach science topics at their assigned grade level. However, although few teachers at any grade level felt well prepared to teach engineering, classes in high-FRL schools were even less likely than classes in low-FRL schools to be taught by teachers who felt well prepared to teach engineering concepts.

Teachers in high-FRL and low-FRL schools felt equally well prepared to implement a number of instructional tasks in their classrooms, but differences by FRL quartile status were also apparent. Notably, teachers of classes in high-FRL schools were somewhat less likely than teachers of classes in low-FRL schools to feel very well prepared to develop students' conceptual understanding or their abilities to do science. Further, teachers in high-FRL schools perceived themselves as less well prepared than teachers in low-FRL schools to implement instruction in their most recent unit (e.g., assess student understanding, anticipate student difficulties).

Regardless of school poverty level, nearly three-quarters of classes were taught by teachers who participated in science-focused professional development in the previous three years. Further, there were few differences in the focus or characteristics of this professional development based on school poverty level.

Between 2012 and 2018, there has been a significant change in only one area related to the distribution of well-prepared teachers. Looking at classes taught by teachers with a degree or 3+ advanced courses in the subject, there was a widening in the gap between high-FRL schools and low-FRL schools. This widening appears to be due to fewer classes in high-FRL schools being taught by teachers with this level of course background in 2018 than in 2012.

Supportive Context for Learning

Student opportunity to learn science is also affected by a number of contextual factors. The 2018 NSSME+ collected information on professional development opportunities offered by the school or district, including workshops, teacher study groups, and formal induction programs. It also asked about science programs and practices, and factors that promote and inhibit effective science instruction in the school. This section presents these data, highlighting the similarities and differences between high-FRL and low-FRL schools.

Locally Offered Professional Development

Science program representatives were asked whether science-focused professional development workshops had been offered by their school and/or district, possibly in conjunction with other school systems, colleges or universities, museums, professional associations, or commercial vendors. About one-third of schools, regardless of poverty level, offered science/engineering-focused study groups and one-on-one science/engineering-focused coaching (see Table 2.34). Interestingly, high-poverty schools were more likely than low-poverty schools to offer science/engineering-focused workshops (56 vs. 44 percent). These data are not significantly different from the data in 2012.

Table 2.34
Types of Locally Offered Science Professional Development Available to Teachers, by FRL Quartile

	PERCENT OF SCHOOLS			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Workshops*	44 (3.6)	51 (5.0)	51 (3.9)	56 (4.6)
(t) Study groups	33 (3.3)	38 (4.3)	36 (4.0)	38 (3.9)
(t) One-on-one science/engineering focused coaching	26 (3.4)	26 (4.3)	26 (3.5)	35 (4.6)

(t) Trend item

* There is a statistically significant difference between schools in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

Science program representatives who indicated that workshops were offered locally in the previous three years were asked about the extent to which those workshops emphasized each of a number of areas. As can be seen in Table 2.35, the areas of emphasis in workshops were similar in the highest and lowest quartiles of schools. For example, 40–60 of schools in the highest and lowest quartiles offered workshops with a substantial emphasis on: (1) deepening teachers' understanding of how science is done, (2) how to use particular science/engineering instructional materials, (3) how to use technology in science/engineering instruction, and (4) how to engage students in doing science.

In contrast, the highest quartile of schools were more likely than the lowest quartile of schools to substantially emphasize deepening teachers' understanding of the science standards (65 vs. 46 percent) and deepening teachers' understanding of science concepts (63 vs. 44 percent). Looking over time, the 2018 data are not significantly different from the 2012 data.

Table 2.35

Locally Offered Science Professional Development Workshops in the Previous Three Years With a Substantial Emphasis[a] in Each of a Number of Areas, by FRL Quartile

	PERCENT OF SCHOOLS			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Deepening teachers' understanding of the state science standards*	46 (7.2)	74 (5.6)	76 (5.1)	65 (5.2)
(t) Deepening teachers' understanding of science concepts*	44 (6.6)	62 (6.0)	59 (5.8)	63 (5.0)
Deepening teachers' understanding of how science is done (e.g., developing scientific questions, developing and using models, engaging in argumentation)	43 (6.3)	62 (6.1)	69 (4.5)	59 (5.2)
(t) How to use particular science/engineering instructional materials (e.g., textbooks or modules)	44 (7.0)	45 (6.5)	39 (6.0)	48 (4.8)
(t) How to use technology in science/engineering instruction	42 (6.6)	45 (6.7)	56 (6.1)	47 (5.0)
How to engage students in doing science (e.g., developing scientific questions, developing and using models, engaging in argumentation)	48 (5.8)	59 (6.6)	60 (5.7)	46 (4.8)
(t) Deepening teachers' understanding of how students think about various science ideas	35 (6.0)	44 (6.8)	59 (5.7)	43 (6.1)
(t) How to monitor student understanding during science instruction	31 (5.9)	45 (6.2)	39 (5.6)	41 (5.1)
Deepening teachers' understanding of how engineering is done (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)	39 (6.4)	51 (6.0)	44 (6.8)	40 (6.4)
How to incorporate real-world issues (e.g., current events, community concerns) into science instruction	30 (5.5)	39 (6.5)	46 (6.3)	36 (4.7)
(t) How to adapt science instruction to address student misconceptions	29 (5.5)	41 (6.9)	37 (5.5)	32 (5.6)
How to engage students in doing engineering (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)	34 (5.3)	45 (6.5)	40 (5.8)	29 (5.1)
How to integrate science, engineering, mathematics, and/or computer science	37 (6.2)	43 (6.7)	34 (5.3)	28 (5.2)
How to differentiate science instruction to meet the needs of diverse learners	26 (5.8)	22 (4.7)	32 (5.5)	27 (5.1)
How to connect instruction to science/engineering career opportunities	30 (6.0)	39 (7.1)	37 (5.1)	21 (4.7)
How to develop students' confidence that they can successfully pursue careers in science/engineering	25 (6.1)	26 (5.7)	29 (5.8)	19 (4.6)
How to incorporate students' cultural backgrounds into science instruction	16 (5.4)	11 (3.6)	17 (4.7)	18 (3.3)

(t) Trend item

* There is a statistically significant difference between schools in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes schools indicating 4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent."

Further, when schools had teacher study groups, program representatives were asked about topics addressed. As can be seen in Table 2.36, the emphases of study groups were quite similar across FRL quartiles. For example, study groups in over half of high-FRL and low-FRL schools were likely to emphasize deepening teachers' understanding of the state science/engineering standards and how to engage students in doing science. Moderate percentages of study groups were also likely to place substantial emphasis on deepening teachers' understanding of how students think about various science ideas, how to use particular science/engineering instructional materials, how to use technology, and deepening teachers' understanding of science concepts.

A few differences are evident between the highest and lowest FRL quartiles. Teacher study groups in highest quartile of schools were more likely than those in lowest quartile of schools to substantially emphasize deepening teachers' understanding of how engineering is done (38 vs. 19 percent), how to connect instruction to science/engineering career opportunities (32 vs. 17 percent), and how to incorporate students' cultural backgrounds into science instruction (25 vs. 13 percent). These emphases all favor teachers of students from historically disadvantaged groups. These data are not significantly different from the data in 2012.

Table 2.36
Locally Offered Science Teacher Study Groups in the Previous Three Years With a Substantial Emphasis[a] in Each of a Number of Areas, by FRL Quartile

	PERCENT OF SCHOOLS			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Deepening teachers' understanding of the state science/engineering standards	60 (5.9)	67 (6.0)	66 (6.5)	71 (5.3)
How to engage students in doing science (e.g., developing scientific questions, developing and using models, engaging in argumentation)	69 (5.3)	58 (6.5)	44 (6.1)	54 (6.8)
(t) Deepening teachers' understanding of how students think about various science ideas	39 (5.1)	39 (5.9)	42 (6.8)	54 (7.4)
(t) How to use particular science/engineering instructional materials (e.g., textbooks or modules)	39 (5.1)	45 (6.5)	48 (7.2)	53 (6.5)
(t) How to use technology in science/engineering instruction	40 (5.8)	50 (6.8)	42 (6.1)	51 (6.5)
(t) Deepening teachers' understanding of science concepts	37 (6.0)	44 (5.8)	29 (5.9)	51 (6.5)
Deepening teachers' understanding of how science is done (e.g., developing scientific questions, developing and using models, engaging in argumentation)	49 (5.7)	47 (6.0)	37 (6.3)	49 (6.6)
How to incorporate real-world issues (e.g., current events, community concerns) into science instruction	37 (4.9)	46 (5.8)	37 (6.1)	49 (7.1)
(t) How to monitor student understanding during science/engineering instruction	43 (5.0)	42 (6.3)	45 (6.0)	47 (6.1)
How to differentiate science instruction to meet the needs of diverse learners	35 (5.3)	31 (5.9)	35 (5.3)	46 (6.1)
(t) How to adapt science instruction to address student misconceptions	37 (5.7)	30 (5.6)	47 (6.5)	39 (5.9)
Deepening teachers' understanding of how engineering is done (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)*	19 (4.1)	42 (6.0)	25 (6.2)	38 (6.6)
How to integrate science, engineering, mathematics, and/or computer science	40 (5.2)	43 (5.9)	29 (5.9)	37 (6.3)
How to engage students in doing engineering (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)	32 (5.1)	49 (5.7)	25 (5.7)	35 (6.5)
How to develop students' confidence that they can successfully pursue careers in science/engineering	20 (4.3)	24 (5.6)	17 (4.3)	34 (6.7)
How to connect instruction to science/engineering career opportunities*	17 (3.7)	33 (6.6)	22 (5.1)	32 (6.4)
How to incorporate students' cultural backgrounds into science instruction*	13 (3.3)	17 (4.8)	13 (3.5)	25 (5.4)

(t) Trend item

* There is a statistically significant difference between schools in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes schools indicating 4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent."

Science program representatives were also asked about services provided to teachers in need of special assistance. Interestingly, there is no variation by school poverty level in the types of services provided (see Table 2.37). In roughly 20–40 percent of all schools, teachers in need were provided with guidance from a formally designated mentor or coach; seminars, classes, and/or study groups; and a higher level of supervision. The 2018 data are not significantly different from the 2012 data.

Table 2.37
Services Provided to Teachers in Need of Special Assistance in Teaching, by FRL Quartile†

	PERCENT OF SCHOOLS			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Guidance from a formally designated mentor or coach	31 (3.5)	36 (4.5)	43 (4.1)	40 (4.9)
(t) Seminars, classes, and/or study groups	20 (3.3)	32 (4.8)	31 (4.4)	32 (4.6)
(t) A higher level of supervision than for other teachers	18 (2.7)	18 (2.7)	22 (3.6)	25 (4.2)

(t) Trend item

† There are no statistically significant differences between the lowest quartile of schools and the highest quartile of schools (two-tailed independent samples t-test, $p \geq 0.05$).

Formal induction programs provide critical support and guidance for beginning teachers and show promise for having a positive impact on teacher retention, instructional practices, and student achievement.[18] However, the effectiveness of these programs greatly depends on their length and the nature of the supports that are offered. Accordingly, representatives were asked a series of questions about formal induction programs at their schools.

In 2018, the percentages of schools offering a formal teacher induction program were evenly distributed, with about three-quarters of all schools offering such a program (see Table 2.38). Regardless of FRL quartile, about 3 in 10 schools had programs that lasted one year or less, and about 4 in 10 schools had programs that lasted two years or more. This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 2.38
Typical Duration of Formal Induction Programs, by FRL Quartile†

	PERCENT OF SCHOOLS			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
No formal induction program	30 (3.6)	21 (3.9)	23 (4.1)	22 (3.8)
One year or less	32 (3.7)	29 (4.0)	36 (4.2)	36 (3.9)
Two years or more	38 (3.5)	49 (4.6)	41 (4.4)	42 (4.3)

† There are no statistically significant differences between schools in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p \geq 0.05$).

[18] Ingersoll, R., & Strong, M. (2011). *The impact of induction and mentoring programs for beginning teachers: A critical review of the research*. Retrieved from https://repository.upenn.edu/gse_pubs/127.

The research on effective induction programs for beginning teachers also suggests a number of supports that are important for a program's success. Therefore, representatives were asked about the availability of several types of support within their school induction program. As can be seen in Table 2.39, three-quarters or more of schools across FRL quartiles provided professional development opportunities on teaching in a beginning teacher's subject, a meeting to orient them to school and district policies and practices, and formally assigned school-based mentors. Conversely, very few schools offered a reduced number of teaching preps, a reduced course load, or reduced class size. There are only a few differences by FRL quartile. Schools in the highest quartile were more likely than those in the lowest quartile to offer professional development opportunities on providing instruction that meets the needs of students from cultural backgrounds represented in the school (62 vs. 39 percent). However, schools in the highest quartile were less likely than those in the lowest quartile to offer financial support to attend national, state, or local teacher conferences (25 vs. 31 percent).

Table 2.39
Supports Provided as Parts of Formal Induction Programs, by FRL Quartile

	PERCENT OF SCHOOLS[a]			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
Professional development opportunities on teaching their subject	75 (3.9)	76 (4.6)	80 (3.5)	85 (2.9)
A meeting to orient them to school district/diocese policies and practices	92 (2.8)	92 (2.6)	87 (3.0)	83 (4.0)
Formally assigned school-based mentor teachers	85 (3.4)	87 (2.7)	87 (2.5)	83 (3.4)
Common planning time with experienced teachers who teach the same subject or grade level	67 (4.6)	71 (3.6)	73 (4.1)	77 (3.3)
Release time to observe other teachers in their grade/subject area	69 (3.8)	67 (4.2)	69 (4.1)	72 (4.5)
Professional development opportunities on providing instruction that meets the needs of students from the cultural backgrounds represented in the school*	39 (4.1)	41 (4.3)	44 (4.5)	62 (4.4)
District/Diocese-level or university-based mentors	23 (3.7)	29 (3.9)	31 (4.0)	36 (4.3)
Supplemental funding for classroom supplies	34 (4.9)	30 (5.0)	23 (3.5)	36 (4.6)
Release time to attend national, state, or local teacher conferences	44 (4.9)	35 (4.2)	33 (3.7)	34 (4.5)
Financial support to attend national, state, or local teacher conferences*	31 (3.9)	23 (4.2)	19 (2.9)	25 (4.1)
Classroom aides/teaching assistants	11 (3.2)	13 (2.8)	13 (3.0)	18 (3.9)
Reduced number of teaching preps	7 (2.4)	2 (0.7)	5 (1.1)	4 (1.1)
Reduced course load	4 (2.1)	0 ---[b]	1 (0.5)	3 (1.8)
Reduced class size*	0 (0.1)	1 (0.8)	1 (0.7)	2 (0.8)

* There is a statistically significant difference between schools in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes only those schools that provide a formal induction program.

[b] No school representatives in this quartile selected this response option. Thus, it is not possible to calculate the standard error of this estimate.

Factors Affecting Student Opportunity to Learn

The NSSME+ asked science program representatives about instructional arrangements, course formats, and other practices that can promote interest in science and support (or inhibit) science instruction. As can be seen in Table 2.40, the use of elementary science specialists (either in place of or in addition to the regular classroom teacher) and pull-out science instruction were uncommon in 2018 across FRL quartiles.

Table 2.40
Use of Various Instructional Arrangements in Elementary Schools,[a] by FRL Quartile[†]

	PERCENT OF SCHOOLS			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Students in self-contained classes are pulled out from science instruction for additional instruction in other content areas.	15 (4.0)	34 (6.5)	38 (6.7)	27 (5.9)
(t) Students in self-contained classes receive instruction from a district/diocese/ school science specialist *in addition* to their regular teacher.	14 (4.1)	12 (3.7)	17 (5.0)	15 (4.8)
(t) Students in self-contained classes are pulled out for enrichment in science.	6 (3.2)	5 (2.4)	12 (4.4)	14 (3.9)
(t) Students in self-contained classes receive instruction from a district/diocese/ school science specialist *instead of* their regular teacher.	10 (3.3)	3 (1.5)	2 (1.2)	9 (3.6)
(t) Students in self-contained classes are pulled out for remedial instruction in science.	6 (4.1)	6 (3.0)	9 (3.7)	8 (3.3)
Students in self-contained classes receive science instruction on a regular basis from someone outside of the school/district/diocese (e.g., museum staff).	3 (1.8)	3 (2.8)	2 (1.7)	4 (2.8)

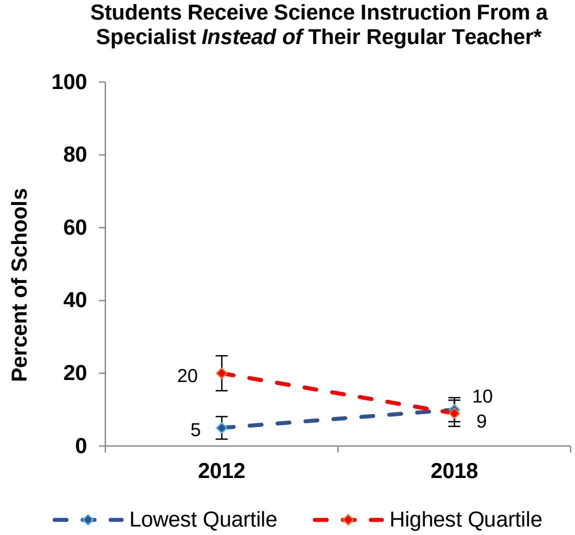
(t) Trend item

† There are no statistically significant differences between schools in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p \geq 0.05$).

a Item was presented only to program representatives whose schools had self-contained teachers.

Although there was no difference in the use of specialists in place of self-contained classroom teachers between high-FRL and low-FRL in 2018, this arrangement was significantly more common in high-FRL schools (20 percent) than low-FRL schools (5 percent) in 2012 (see Figure 2.5). The data show a decreased use of specialists in high-FRL schools over time (20 percent in 2012 vs. 10 percent in 2018).

Change Over Time: Elementary Instructional Arrangements



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between schools in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

Figure 2.5

At the high school level, the NSSME+ asked about a number of specific course-taking opportunities and formats provided to students. As can be seen in Table 2.41, there were few significant differences in students' access to these opportunities based on school poverty level. The one exception is the availability of physics courses; high-poverty schools were less likely than low-poverty schools to offer physics courses (78 vs. 97 percent). When looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 2.41
Science Course-Taking Options in High Schools, by FRL Quartile

	PERCENT OF SCHOOLS			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Physics courses are offered this school year or in alternating years, on or off site.*	97 (1.8)	91 (5.1)	83 (7.6)	78 (6.5)
(t) Concurrent college and high school credit/dual enrollment courses are offered this school year or in alternating years.	35 (5.1)	52 (7.0)	46 (6.3)	51 (7.2)
(t) Students can go to a college or university for science and/or engineering courses.	53 (5.8)	58 (6.3)	55 (7.1)	50 (6.7)
(t) Students can go to a Career and Technical Education center for science and/or engineering instruction.	27 (4.7)	51 (5.2)	47 (5.8)	38 (6.1)
This school provides students access to virtual science and/or engineering courses offered by other schools/institutions.	28 (4.3)	47 (7.6)	53 (6.8)	37 (6.5)
(t) Students can go to another K–12 school for science and/or engineering courses.	14 (3.3)	19 (4.3)	16 (4.8)	18 (5.1)
This school provides its own science and/or engineering courses virtually.	10 (4.2)	17 (4.4)	17 (4.5)	16 (4.1)

(t) Trend item

* There is a statistically significant difference between schools in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

Program representatives were also asked to indicate which of several programs and practices their school employed to enhance student interest and/or achievement in science. As can be seen in Table 2.42, the data are mixed. More than one-third of high-FRL and low-FRL schools offered family nights, after-school programs for enrichment, and science clubs. However, high-FRL schools were significantly more likely than low-FRL schools to provide after-school help (55 vs. 39 percent). Conversely, high-FRL schools were less likely than low-FRL schools to offer engineering clubs or engineering competitions (26 vs. 39 percent and 25 vs. 36 percent, respectively). The 2018 data are not significantly different from the 2012 data.

Table 2.42
School Programs/Practices to Enhance Students' Interest in Science and/or Engineering, by FRL Quartile

	PERCENT OF SCHOOLS			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) After-school help*	39 (3.6)	44 (4.8)	43 (4.0)	55 (4.4)
(t) Family nights	35 (3.9)	38 (4.0)	37 (3.9)	43 (4.9)
(t) After-school programs for enrichment	38 (4.5)	33 (3.8)	32 (3.9)	39 (4.2)
(t) Science clubs	47 (3.9)	40 (4.2)	44 (4.1)	38 (4.9)
(t) Engineering clubs*	39 (3.6)	33 (3.8)	30 (3.8)	26 (3.5)
(t) Engineering competitions*	36 (3.6)	39 (4.3)	25 (3.3)	25 (3.7)
(t) Science competitions	25 (2.8)	27 (3.3)	26 (3.4)	20 (3.9)

(t) Trend item

* There is a statistically significant difference between schools in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

Table 2.43 shows the percentage of science program representatives who viewed various factors as promoting effective science instruction in their schools. Overall, there are no significant differences between high-FRL and low-FRL schools. Representatives from about half of all high-FRL and low-FRL schools thought that science professional development policies and practices, how instructional resources are managed, and the importance that the school places on science tend to promote effective instruction. The 2018 data are not significantly different from the 2012 data.

Table 2.43
Factors Promoting Effective Science Instruction, by FRL Quartile†

	PERCENT OF SCHOOLS			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) The school/district/diocese science professional development policies and practices	47 (4.4)	52 (4.9)	56 (5.0)	55 (4.2)
(t) How science instructional resources are managed (e.g., distributing and refurbishing materials)	51 (4.8)	47 (4.7)	45 (4.2)	51 (4.7)
(t) The importance that the school places on science	51 (4.2)	61 (4.9)	44 (4.1)	49 (5.2)
(t) Other school and/or district/diocese initiatives	30 (4.3)	38 (4.7)	31 (3.5)	41 (4.7)
The amount of time provided by the school/district/diocese for teachers to share ideas about science instruction	37 (4.0)	36 (4.8)	34 (4.0)	40 (4.9)
(t) The amount of time provided by the school/district/diocese for teacher professional development in science	31 (4.3)	40 (4.3)	38 (3.9)	35 (5.1)

(t) Trend item

† There are no statistically significant differences between schools in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p \geq 0.05$).

A subset of these items were combined into a composite variable in order to look at these effects more holistically. As can be seen in Table 2.44, the context for science instruction was moderately supportive across FRL quartiles. Looking over time, these data are not significantly different from the data in 2012.

Table 2.44
School Mean Scores for the Supportive Context for Science Instruction Composite,[a] by FRL Quartile[(t),†]

	MEAN SCORE
Lowest Quartile Schools	63 (2.6)
Second Quartile Schools	76 (2.1)
Third Quartile Schools	71 (2.4)
Highest Quartile Schools	70 (2.1)

(t) Trend composite

† There is no statistically significant difference between schools in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p \geq 0.05$).

a This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed using only the items in common at both time points. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Science program representatives were also asked to indicate whether a number of factors were problematic for science instruction in their school. As can be seen in Table 2.45, a discouraging pattern exists. Several factors were significantly more likely to be rated as problematic in high-poverty schools than low-poverty schools, including:

- Low student prior knowledge and skills (85 vs. 49 percent);
- Insufficient instructional time to teach science (71 vs. 54 percent):
- Lack of parent/guardian support and involvement (69 vs. 25 percent);
- Inappropriate student behavior (63 vs 28 percent);
- High student absenteeism (56 vs. 20 percent);
- Large class sizes (55 vs. 40 percent);
- Lack of science textbooks/modules (54 vs. 40 percent);
- Low student interest in science (51 vs. 23 percent); and
- High teacher turnover (50 vs. 21 percent).

Further, there have not been changes in this area over time. The 2018 data are not significantly different from the 2012 data.

Table 2.45
Science Program Representatives Viewing Each of a Number of Factors as a Problem[a] for Science Instruction in Their School, by FRL Quartile

	PERCENT OF SCHOOLS			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
Low student prior knowledge and skills*	49 (4.0)	63 (4.4)	78 (3.6)	85 (3.5)
(t) Inadequate science-related professional development opportunities	68 (4.2)	70 (4.2)	69 (4.1)	72 (3.1)
(t) Insufficient instructional time to teach science*	54 (3.9)	57 (4.4)	64 (4.2)	71 (3.6)
(t) Inadequate materials for differentiating science instruction	59 (4.5)	58 (4.5)	70 (3.8)	69 (3.8)
(t) Lack of parent/guardian support and involvement*	25 (3.6)	46 (4.2)	67 (4.6)	69 (4.3)
(t) Inadequate funds for purchasing science equipment and supplies	54 (4.4)	56 (4.6)	64 (4.4)	66 (4.1)
(t) Inappropriate student behavior*	28 (3.9)	39 (3.8)	56 (4.8)	63 (4.2)
(t) Lack of science facilities (e.g., lab tables, electric outlets, faucets and sinks in classrooms)	51 (4.2)	50 (5.0)	52 (5.3)	60 (4.6)
(t) Inadequate teacher preparation to teach science	49 (3.9)	41 (4.7)	45 (4.2)	57 (4.7)
(t) High student absenteeism*	20 (3.1)	33 (4.0)	59 (4.4)	56 (4.3)
(t) Large class sizes*	40 (3.9)	46 (4.5)	49 (4.4)	55 (4.5)
(t) Lack of science textbooks/modules*	40 (4.5)	37 (4.2)	46 (4.9)	53 (4.2)
(t) Low student interest in science*	23 (3.3)	39 (4.7)	41 (3.8)	51 (4.7)
Poor quality science textbooks/modules	47 (4.0)	45 (4.4)	48 (4.5)	50 (5.1)
High teacher turnover*	21 (3.6)	23 (3.8)	43 (4.4)	50 (5.3)
(t) Lack of teacher interest in science	34 (3.9)	27 (4.2)	35 (4.7)	43 (4.8)
(t) Community resistance to the teaching of "controversial" issues in science (e.g., evolution, climate change)	17 (3.5)	18 (3.6)	19 (3.0)	17 (3.3)

(t) Trend item

* There is a statistically significant difference between schools in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes schools indicating "somewhat of a problem" or "serious problem" on a three-point scale from 1 "not a significant problem" to 3 "serious problem."

Composite variables created from these allow for a summary of the factors affecting science instruction (see Table 2.46). The Extent to Which Student Issues are Problematic composite consists of the following items:

- Low student interest in science;
- Low student prior knowledge and skills;
- High student absenteeism;
- Inappropriate student behavior;
- Lack of parent/guardian support and involvement; and
- Community resistance to the teaching of "controversial" issues in science.

For Extent to Which a Lack of Resources is Problematic, the items are:

- Lack of science facilities
- Lack of science textbooks/modules;
- Poor quality science textbooks/modules;
- Inadequate materials for differentiating science instruction; and
- Inadequate funds for purchasing science equipment and supplies.

Items for the Extent to Which Teacher Issues are Problematic composite are:

- Lack of teacher interest in science;
- Inadequate teacher preparation to teach science;
- Insufficient instructional time to teach science; and
- Inadequate science-related professional development opportunities.

The mean scores for each composite are higher for high-FRL schools than for low-FRL schools, indicating that high-FRL schools perceived each of these factors as more problematic than did low-FRL schools. The 2018 data for the Extent to Which Lack of Resources is Problematic and Extent to Which Student Issues Are Problematic composites are not significantly different from the 2012 data.[19]

[19] The 2012 data did not support the creation of the Extent to Which Teacher Issues Are Problematic composite; thus, trend data are not available to report.

Table 2.46
School Mean Scores for Factors Affecting Science Instruction Composites, by FRL Quartile

	MEAN SCORE			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
Extent to Which Teacher Issues Are Problematic*	33 (2.1)	30 (2.2)	35 (2.3)	41 (2.5)
(t) Extent to Which a Lack of Resources Is Problematic*,[a]	32 (2.5)	31 (2.3)	38 (2.8)	40 (2.1)
(t) Extent to Which Student Issues Are Problematic*,[b]	16 (1.5)	24 (1.6)	33 (1.8)	38 (2.1)

(t) Trend composite

* There is a statistically significant difference between schools in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed for 2018 using the 2012 definition. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

[b] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed using only the items in common at both time points. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Teachers were also asked about factors that affect science instruction in their classes. As can be seen in Table 2.47, over half of all classes, regardless of FRL quartile, were taught by teachers who rated principal support, the amount of planning time, current state standards, the amount of time available for professional development, and college entrance requirements as promoters of effective science instruction. However, teachers of classes in high-FRL schools were less likely than those in classes of low-FRL schools to rate students' motivation, interest, and effort in science (59 vs. 74 percent), students' prior knowledge and skills (51 vs. 66 percent), or parent/guardian expectations and involvement (32 vs. 49 percent) as factors promoting effective science instruction.

Table 2.47
Factors Promoting[a] Effective Instruction in Science Classes, by FRL Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Principal support	71 (2.8)	65 (2.9)	66 (2.8)	62 (3.9)
(t) Amount of time for you to plan, individually and with colleagues	66 (3.0)	60 (2.8)	61 (2.3)	62 (3.7)
(t) Students' motivation, interest, and effort in science*	74 (2.5)	69 (2.5)	66 (2.9)	59 (3.4)
(t) Current state standards	61 (2.9)	66 (3.1)	65 (2.3)	59 (3.4)
(t) Amount of time available for your professional development	52 (3.1)	45 (2.8)	44 (2.0)	52 (4.2)
Students' prior knowledge and skills*	66 (2.7)	63 (2.6)	55 (2.7)	51 (4.1)
(t) College entrance requirements[b]	53 (4.3)	53 (4.0)	53 (4.6)	50 (4.9)
(t) Pacing guides	58 (3.2)	54 (3.3)	51 (3.4)	48 (3.8)
Amount of instructional time devoted to science[c]	52 (6.3)	48 (4.9)	49 (3.6)	45 (5.0)
(t) Teacher evaluation policies	38 (3.3)	44 (2.7)	40 (3.0)	38 (4.0)
(t) Textbook/module selection policies	35 (3.4)	32 (3.5)	37 (3.1)	33 (2.8)
(t) State/district/diocese testing/accountability policies[d]	33 (2.9)	34 (3.1)	36 (3.0)	33 (3.4)
(t) Parent/guardian expectations and involvement*	49 (3.4)	38 (2.9)	38 (2.5)	32 (2.6)

(t) Trend Item

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes science teachers indicating 4 or 5 on a five-point scale ranging from 1 "inhibits effective instruction" to 5 "promotes effective instruction."

[b] This item was presented only to high school teachers.

[c] This item was presented only to elementary school teachers.

[d] This item was presented only to teachers in public and Catholic schools.

Since 2012, the gap between high-FRL and low-FRL schools has narrowed in terms of the extent to which teacher evaluation policies promote effective science instruction (see Figure 2.6). This narrowing appears to be due to fewer teachers in low-FRL schools seeing this factor as promoting effective science instruction in 2018 (38 percent) compared to 2012 (57 percent).

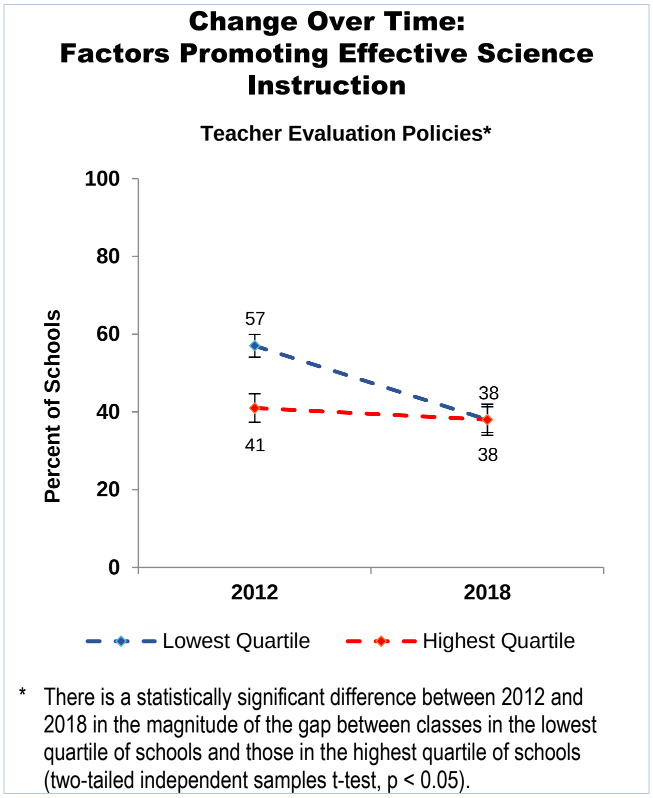


Figure 2.6

Three composites were created from the items in Table 2.47: (1) Extent to Which School Support Promotes Effective Instruction (i.e., amount of time for professional development, and amount of planning time); (2) Extent to Which the Policy Environment Promotes Effective Instruction (i.e., testing/accountability, textbook selection, pacing guides, teacher evaluation, and current state standards); and (3) Extent to Which Stakeholders Promote Effective Instruction (i.e., students' motivation and interest, students' prior knowledge, parent/guardian expectations and involvement). The mean scores for these composites are shown in Table 2.48. Each of these factors appears to have a moderate influence on instruction at the class level. There are no significant differences between the highest and lowest quartiles for the school support or policy environment composites. However, the composite mean score for classes in highest quartile of schools is significantly lower than composite mean score for classes in lowest quartile for the Extent to Which Stakeholders Promote Effective Instruction composite (mean scores of 60 vs. 71). Looking at trends, the 2018 data for the school support and policy environment composites are not significantly different from the 2012 data.[20]

[20] Too few of the items in the 2018 version of the Extent to Which Stakeholders Promote Effective Instruction composite were also asked in 2012 to allow for a comparison over time.

Table 2.48
Science Class Mean Scores for Factors Affecting Instruction Composites, by FRL Quartile

	MEAN SCORE			
	LOWEST QUARTILE SCHOOLS	SECOND QUARTILE SCHOOLS	THIRD QUARTILE SCHOOLS	HIGHEST QUARTILE SCHOOLS
(t) Extent to Which School Support Promotes Effective Instruction	68 (1.8)	63 (1.9)	63 (1.5)	65 (2.6)
Extent to Which Stakeholders Promote Effective Instruction*	71 (1.4)	68 (1.2)	63 (1.4)	60 (2.4)
(t) Extent to Which the Policy Environment Promotes Effective Instruction[a]	63 (1.2)	62 (1.4)	62 (1.3)	60 (1.2)

(t) Trend composite

* There is a statistically significant difference between classes in the lowest quartile of schools and those in the highest quartile of schools (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed for 2012 using the 2018 definition.

Summary

There were both similarities and differences in the supportiveness of school context for science learning between high-FRL and low-FRL schools. In terms of school-level professional development offerings, study groups and one-on-one coaching were offered in about one-third of schools, regardless of FRL status. The emphases of study groups were quite similar across FRL quartiles. Further, although high-FRL schools were more likely than low-FRL schools to offer science/engineering focused workshops, the emphases of these workshops were consistent across schools. Further, schools, regardless of poverty level, were similar in the services provided to teachers in need of assistance (e.g., seminars, classes, and/or study groups) and those new to the profession (i.e., formally assigned school-based mentors).

The use of different instructional arrangements at the elementary level, such as elementary science specialists (either in place of or in addition to the regular classroom teacher) and pull-out science instruction, was similar regardless of poverty status. With the exception of physics, there was also a great deal of consistency across schools at the high school level in course taking opportunities and formats.

There was variation in schools' use of programs and practices to enhance student interest and achievement in science. About one-third of schools, regardless of poverty level, offered family nights, after-school programs for enrichment, and science clubs. However, high-poverty schools were less likely than low-poverty schools to offer engineering clubs or engineering competitions.

The climate for science instruction was generally seen as moderately supportive in both high-FRL and low-FRL schools. However, teacher issues (e.g., high teacher turnover), lack of resources (e.g., science textbooks/modules), and student issues (e.g., low prior knowledge and skills) were all significantly more likely to be viewed as a problem for science instruction in high-FRL schools than in low-FRL schools. Further, although factors such as principal support and planning time were viewed by teachers as promoters of science instruction in over half of high-FRL and low-FRL schools, there were some differences. For example, teachers in high-FRL schools were less likely than those in low-FRL schools to rate students' motivation, interest, and effort in science; students' prior knowledge and skills; and parent/guardian expectations and involvement as promoters of science instruction.

Over time, there have been only a couple of significant changes between high-FRL and low-FRL schools in terms of the supportiveness of context for science instruction. In one instance, the use of specialists to provide science instruction has become more similar between high-FRL and low-FRL schools. This narrowing of the gap seems to be due to the decrease in the prevalence of this instructional arrangement in high-FRL schools from 2012 to 2018. In another instance, the gap between high-FRL schools and low-FRL schools has narrowed in terms of the extent to which external evaluation policies promote effective science instruction, as fewer teachers in 2018 compared to 2012 in low-FRL schools perceived this factor as a promotor of effective science instruction.

Community Type

Table 3.1 provides information about the national distribution of schools in each community type in 2018. Suburban schools made up nearly half of all schools in the nation while rural and urban schools each made up about one-quarter of all schools. This chapter shows study data for schools in each community type and highlights differences found when making comparisons among the three groups.

Table 3.1
Percentage of Schools in Each Community Type

	PERCENT OF SCHOOLS
Rural	26 (0.8)
Suburban	45 (0.7)
Urban	29 (0.8)

Nature of Science Instruction

As described in Chapter 2, the 2018 NSSME+ collected a variety of data about student opportunity to learn important science concepts. This section presents data on science course offerings and instruction, highlighting the similarities and differences among the three community types.

Time Spent on Various Subjects In Elementary Grades

Table 3.2 shows the average number of minutes per day typically spent on science, reading/ language arts, mathematics, and social studies in elementary grades self-contained classes. Students in urban settings spent more time on science than students in suburban or rural settings, though in each setting the amount of time devoted to science was low. Further, time spent on science instruction was substantially less than time spent on reading/language arts or mathematics. Looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 3.2
Average Number of Minutes Per Day Spent Teaching Each Subject in Elementary Grades Self-Contained Classes,[a] by Community Type

	NUMBER OF MINUTES		
	RURAL	SUBURBAN	URBAN
(t) Reading/Language Arts	86 (2.9)	85 (1.7)	92 (3.1)
(t) Mathematics	59 (2.0)	57 (1.0)	60 (1.7)
(t) Science*	18 (0.9)	19 (0.6)	22 (1.1)
(t) Social Studies	17 (0.8)	16 (0.5)	18 (0.8)

(t) Trend item

* There is a statistically significant difference between classes in schools serving urban communities and those serving other community types (two-tailed independent samples t-tests, $p < 0.05$).

[a] Includes only self-contained elementary teachers who indicated they teach reading, mathematics, science, and social studies to one class of students.

Course-Taking Opportunities in High School

At the high school level, teachers were asked to provide information about a randomly selected class, including the course type, which allows for an estimate of the percentage of science courses of each type in schools. As can be seen in Table 3.3, the distribution of courses is similar among community types and are not significantly different than in 2012.

Table 3.3
Prevalence of High School Science Courses, by Community Type(t),†

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
Non-college prep	32 (3.4)	27 (1.9)	24 (2.8)
1st year biology	24 (3.6)	22 (2.0)	21 (3.0)
1st year chemistry	13 (2.0)	16 (1.2)	16 (2.1)
1st year physics	8 (1.8)	8 (0.8)	9 (1.6)
1st year multi-discipline science courses	6 (2.0)	4 (0.7)	7 (1.8)
1st year environmental science	2 (0.8)	2 (0.5)	4 (2.2)
1st year Earth/space science	2 (0.9)	2 (0.7)	1 (0.8)
Advanced science courses	14 (2.4)	19 (2.3)	17 (2.2)

(t) Trend item

† There are no statistically significant differences in the distribution among classes in schools serving different community types (Chi-square test of independence, $p \geq 0.05$).

Teachers' Perceptions of Their Decision-Making Autonomy

A number of differences are evident by community type in teachers' perceptions of control over pedagogical decisions, with greater control found in rural schools (see Table 3.4). For example, classes in rural schools were more likely than classes in suburban or urban schools to be taught by teachers feeling strong control over determining the amount of homework to be assigned (75, 63, and 65 percent, respectively), selecting teaching techniques (67, 53, and 56 percent, respectively), and selecting criteria for grading student performance (60, 46, and 44 percent, respectively).

Differences by community type are also evident for teachers' perceptions of control over curricular decisions, again with greater control found in rural schools. For example, classes in rural schools were more likely than classes in suburban schools to be taught by teachers feeling strong control over determining course goals and objectives (32 vs. 22 percent), selecting curriculum materials (32 vs. 21 percent), and selecting content, topics, and skills to be taught (31 vs. 17 percent).

Table 3.4
Science Classes in Which Teachers Felt Strong Control Over Various Curricular and Instructional Decisions, by Community Type

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
(t) Determining the amount of homework to be assigned*1	75 (2.1)	63 (1.9)	65 (3.3)
(t) Selecting teaching techniques*1	67 (2.4)	53 (1.6)	56 (3.3)
(t) Choosing criteria for grading student performance*1	60 (2.7)	46 (2.1)	44 (3.7)
Selecting the sequence in which topics are covered*1	50 (2.7)	34 (1.5)	35 (4.2)
Determining the amount of instructional time to spend on each topic*1	46 (2.6)	29 (1.6)	31 (4.3)
(t) Determining course goals and objectives*2	32 (2.7)	22 (1.5)	27 (4.0)
(t) Selecting curriculum materials (e.g., textbooks/online courses)*2	32 (2.6)	21 (1.4)	22 (4.2)
(t) Selecting content, topics, and skills to be taught*2	31 (2.9)	17 (1.2)	22 (4.1)

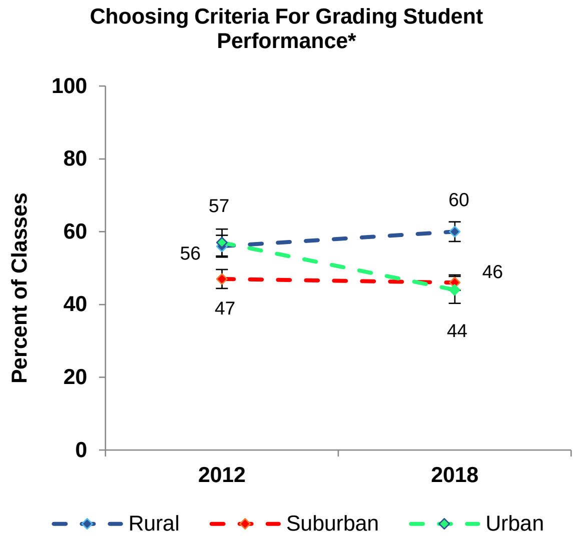
(t) Trend item

*1 There is a statistically significant difference between classes in schools serving rural communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between classes in schools serving rural communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

Looking at trends, the gap between the percentages of classes in rural schools and those in urban schools taught by teachers who felt strong control over choosing criteria for grading student performance has widened since 2012 (see Figure 3.1). Specifically, 56 percent of classes in rural schools and 57 percent in suburban schools were taught by teachers who felt strong control in this area in 2012, compared to 60 and 44 percent of classes in 2018, respectively.

Change Over Time: Curriculum and Pedagogy Control



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes in schools serving rural communities and those serving urban communities (two-tailed independent samples t-test, $p < 0.05$).

Figure 3.1

The items related to decision making were combined into two composite variables—Curriculum Control and Pedagogy Control. Table 3.5 shows the mean scores on these composites by community type. The data indicate that teachers across community types were more likely to perceive strong control over pedagogical decisions than over curricular decisions. Further, teachers of classes in rural schools were more likely to feel strong curriculum control than teachers of classes in suburban schools and more likely to feel strong pedagogy control than teachers of classes in suburban or urban schools. Similar disparities were present in 2012.

Table 3.5
Science Class Mean Scores for Curriculum Control and Pedagogy Control Composites, by Community Type

	MEAN SCORE		
	RURAL	SUBURBAN	URBAN
(t) Curriculum Control*[1,a]	61 (1.6)	52 (1.0)	52 (3.4)
(t) Pedagogy Control*[2]	87 (1.0)	81 (0.8)	82 (1.8)

(t) Trend composite

*1 There is a statistically significant difference between classes in schools serving rural communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between classes in schools serving rural communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

a This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed for 2018 using the 2012 definition. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Instructional Objectives

What teachers emphasize in their science instruction can heavily influence students' opportunities to learn. As can be seen in Table 3.6, classes in rural, suburban, and urban schools had relatively equal emphasis on each of these instructional objectives. For example, about 60 percent of classes emphasized understanding science concepts. Learning how to do science and increasing students' interest in science/engineering were both emphasized in about one-third of classes. Conversely, few classes emphasized learning about different fields of science/engineering or learning how to do engineering. The 2018 data are not significantly different from the 2012 data.

Table 3.6
Science Classes With Heavy Emphasis on Various Instructional Objectives, by Community Type†

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
(t) Understanding science concepts	60 (2.3)	61 (1.5)	61 (2.6)
Learning how to do science (develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)	33 (2.3)	35 (1.6)	36 (3.3)
(t) Increasing students' interest in science/engineering	25 (1.8)	30 (1.4)	33 (3.3)
Learning science vocabulary and/or facts	28 (2.1)	30 (1.7)	32 (2.5)
Developing students' confidence that they can successfully pursue careers in science/engineering	25 (1.8)	28 (1.4)	30 (3.2)
(t) Learning about real-life applications of science/engineering	24 (1.7)	24 (1.6)	25 (3.4)
(t) Learning test-taking skills/strategies	20 (2.0)	22 (1.1)	21 (2.0)
Learning about different fields of science/engineering	6 (0.9)	7 (0.7)	11 (3.3)
Learning how to do engineering (e.g., identify criteria and constraints, design solutions, optimize solutions)	6 (0.9)	7 (0.9)	11 (3.2)

(t) Trend item

† There are no statistically significant differences among classes in schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

The objectives related to reform-oriented instruction were combined into a composite variable. The mean scores indicate that science classes were, on average, equally likely to emphasize reform-oriented instructional objectives, regardless of community type (see Table 3.7). The 2018 data are not significantly different from the 2012 data.

Table 3.7
Science Class Mean Scores for the Reform-Oriented Instructional Objectives Composite,[a] by Community Type(t), †

	MEAN SCORE
Rural	62 (0.8)
Suburban	63 (0.7)
Urban	64 (1.4)

(t) Trend composite

† There are no statistically significant differences among classes in schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

a This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed using only the items in common at both time points. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Class Activities

The types of activities used in classrooms are also indicators of the nature of science instruction students receive and their opportunities to learn. The 2018 NSSME+ included several sets of items that provided information about how science was taught in a randomly selected class. One set of items asked how often different pedagogies were used. As can be seen in Table 3.8, more than 85 percent of classes across community types included the teacher explaining science ideas to the whole class and engaging the whole class in discussions. Although small group work was also common in classes across community types, it was less likely to be utilized in rural schools than in suburban or urban schools (74, 81, and 82 percent, respectively). Classes in rural schools were also less likely to do hands-on/laboratory activities than classes in suburban schools (54 vs. 61 percent) and less likely to write their reflections than classes in suburban and urban schools (32, 40, and 46 percent, respectively). The differences in the use of these activities by community type have not changed significantly since 2012.

Table 3.8
Science Classes in Which Teachers Used Various Activities at Least Once a Week, by Community Type

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
(t) Explain science ideas to the whole class	90 (1.3)	89 (1.0)	87 (2.9)
(t) Engage the whole class in discussions	87 (1.4)	86 (1.0)	87 (1.2)
(t) Have students work in small groups*1	74 (2.4)	81 (1.2)	82 (2.2)
(t) Have students do hands-on/laboratory activities*2	54 (2.0)	61 (1.6)	59 (2.6)
(t) Focus on literacy skills (e.g., informational reading or writing strategies)	48 (2.5)	49 (1.6)	51 (2.9)
(t) Have students write their reflections (e.g., in their journals, on exit tickets) in class or for homework*1	32 (2.1)	40 (1.8)	46 (2.6)
(t) Have students read from a textbook, module, or other material in class, either aloud or to themselves	36 (2.5)	33 (1.4)	35 (2.3)
(t) Engage the class in project-based learning (PBL) activities	28 (2.3)	30 (1.5)	28 (2.9)
(t) Have students practice for standardized tests	18 (1.9)	17 (1.2)	21 (2.1)
Use flipped instruction (have students watch lectures/demonstrations outside of class to prepare for in-class activities)	9 (1.2)	11 (0.9)	14 (1.7)

(t) Trend item

*1 There is a statistically significant difference between classes in schools serving rural communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between classes in schools serving rural communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

In 2018, teachers were also asked how often they engage students in various aspects of the science practices. As can be seen in Table 3.9, modest percentages of classes across community types engaged in any of the practices on a weekly basis. Further, although there were few differences by community type, most of the differences noted were in favor of classes in urban schools. Classes in urban schools were more likely than classes in suburban or rural schools to make and support claims with evidence (48, 40, and 34 percent, respectively). Classes in urban schools were also more likely than classes in rural schools to use multiple sources of evidence to develop an explanation (36 vs. 26 percent), revise their explanations based on additional evidence (30 vs. 21 percent), use data and reasoning to defend a claim or refute alternative claims (26 vs. 17 percent), and determine what details about an investigation might persuade a targeted audience about a scientific claim (17 vs. 10 percent). There were also two differences between classes in rural and suburban schools. Classes in rural schools were less likely than classes in suburban schools to make and support claims with evidence (34 vs. 40 percent) and use data and reasoning to defend a claim or refute alternative claims (17 vs. 22 percent). This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 3.9
Science Classes in Which Students Engaged in Various Aspects of Science Practices at Least Once a Week, by Community Type

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
Organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data	41 (1.9)	42 (1.5)	49 (2.8)
Make and support claims with evidence*1	34 (2.2)	40 (1.4)	48 (2.7)
Conduct a scientific investigation	39 (2.2)	42 (1.8)	45 (3.0)
Generate scientific questions	36 (2.2)	37 (1.6)	44 (3.4)
Analyze data using grade-appropriate methods in order to identify patterns, trends, or relationships	34 (2.1)	34 (1.5)	40 (3.1)
Determine what data would need to be collected in order to answer a scientific question	30 (1.9)	34 (1.5)	37 (3.4)
Develop procedures for a scientific investigation to answer a scientific question	28 (1.7)	30 (1.4)	36 (3.4)
Use multiple sources of evidence to develop an explanation*2	26 (1.9)	30 (1.4)	36 (3.1)
Develop scientific models—physical, graphical, or mathematical representations of real-world phenomena	23 (1.8)	25 (1.2)	30 (2.9)
Revise their explanations based on additional evidence*2	21 (2.1)	25 (1.4)	30 (2.9)
Compare data from multiple trials or across student groups for consistency in order to identify potential sources of error or inconsistencies in the data	25 (1.6)	24 (1.2)	30 (3.2)
Summarize patterns, similarities, and differences in scientific information obtained from multiple sources	19 (1.7)	21 (1.2)	27 (3.4)
Determine whether or not a question is scientific	21 (1.8)	24 (1.4)	26 (2.7)
Use data and reasoning to defend, verbally or in writing, a claim or refute alternative scientific claims*3	17 (1.6)	22 (1.3)	26 (2.7)
Consider how missing data or measurement error can affect the interpretation of data	17 (1.5)	18 (1.0)	23 (2.5)
Select and use grade-appropriate mathematical and/or statistical techniques to analyze data	20 (1.5)	21 (1.2)	20 (1.9)
Pose questions that elicit relevant details about the important aspects of a scientific argument	17 (1.7)	18 (1.2)	20 (1.9)
Identify the strengths and limitations of a scientific model—in terms of accuracy, clarity, generalizability, accessibility to others, strength of evidence supporting it	15 (1.5)	15 (1.1)	20 (3.0)
Use mathematical and/or computational models to generate data to support a scientific claim	17 (1.7)	17 (1.1)	18 (1.8)
Evaluate the credibility of scientific information—e.g., its reliability, validity, consistency, logical coherence, lack of bias, or methodological strengths and weaknesses	13 (1.6)	14 (1.1)	18 (1.9)
Evaluate the strengths and weaknesses of competing scientific explanations	15 (1.5)	15 (1.1)	17 (2.0)
Determine what details about an investigation might persuade a targeted audience about a scientific claim*2	10 (1.3)	13 (1.2)	17 (2.1)
Construct a persuasive case, verbally or in writing, for the best scientific model or explanation for a real-world phenomenon	10 (1.3)	13 (1.2)	14 (1.5)

*1 There are statistically significant differences among classes in schools serving each of the community types (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between classes in schools serving rural communities and those serving urban communities (two-tailed independent samples t-test, $p < 0.05$).

*3 There is a statistically significant difference between classes in schools serving rural communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

Table 3.10 shows the mean scores for the Engaging Students in the Practices of Science composite formed from the items in the previous table. The mean scores indicate that classes were not likely to engage students in the practices of science very frequently, regardless of community type.

Table 3.10
Science Class Mean Scores for Engaging Students in Practices of Science Composite, by Community Type†

	MEAN SCORE
Rural	43 (0.9)
Suburban	44 (0.6)
Urban	47 (1.2)

† There are no statistically significant differences among classes in schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

The survey also asked how often students in the randomly selected class were required to take assessments the teacher did not develop, such as state or district benchmark assessments. As can be seen in Table 3.11, about one-third of classes across community types were likely to be tested two or more times per year. The 2018 data are not significantly different from the 2012 data.

Table 3.11
Science Classes Required to Take External Assessments Two or More Times Per Year, by Community Type(t),†

	MEAN SCORE
Rural	30 (2.9)
Suburban	32 (1.8)
Urban	30 (3.6)

(t) Trend composite

† There are no statistically significant differences among classes in schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

Summary

A number of aspects of science instruction were similar across community types in 2018. However, there are also some notable differences. In terms of access to science instruction, elementary students in urban schools spent more time on science than students in suburban or rural schools. At the high school level, the distribution of courses offered was similar cross community types.

Data about teachers' perceptions of control and emphasis on instructional objectives were also mixed. In general, teachers were more likely to feel strong control over pedagogical decisions than over curricular decisions. However, teachers in rural schools felt more control over decisions related to pedagogy than teachers in suburban and urban schools and more control over decisions related to curriculum than teachers in suburban schools. Classes across community types had relatively equal emphasis on reform-oriented instructional objectives, such as understanding science concepts, learning how to do science, and increasing students' interest in science/ engineering.

Types of instructional activities used in classrooms were generally similar regardless of community type. Prominent activities included the teacher explaining science ideas to the class and engaging the class in discussions. However, students in rural settings were more likely than those in suburban and urban settings to work in small groups and write reflections on what they were learning. Students in classes across community types also had limited opportunities to engage in the science practices. However, classes in rural schools were even less likely than their suburban and urban counterparts to have students make and support claims with evidence. They were also less likely than classes in urban schools to use multiple sources of evidence to develop an explanation and revise their explanations based on additional evidence.

Since 2012, the nature of science instruction provided across community types has remained largely consistent, with only one notable difference. The gap between the percentages of classes in rural schools and those in urban schools taught by teachers feeling strong control over choosing criteria for grading student performance has widened since 2012, with teachers in urban schools feeling even less control in this area.

Material Resources

As described in Chapter 2, the 2018 NSSME+ included items on teachers' use of instructional materials—which ones and how they use them—as well as the adequacy of other resources for science instruction. This section of the report examines these data by community type.

Instructional Materials

In 2018, over half of all science classes had instructional materials designated for use by the district (see Table 3.12). However, classes in rural schools were less likely than classes in suburban or urban schools to have district-designated materials (58, 68, and 71 percent, respectively). Commercially published textbooks were by far the most frequently designated type of material across community types, while the use of lessons or resources from websites that are free or have a subscription fee was less common. Comparing community types, there is only one significant difference in the types of designated instructional materials. Classes in rural schools were less likely than classes in urban schools to be designated to use commercially published kits/modules (31 vs. 42 percent). This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 3.12
Types of Instructional Materials Designated for Science Classes, by Community Type

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
District Designates Instructional Materials*1			
No	42 (2.4)	32 (1.6)	29 (3.7)
Yes	58 (2.4)	68 (1.6)	71 (3.7)
Types of Designated Instructional Materials[a]			
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	80 (3.8)	77 (2.5)	76 (3.3)
Commercially published kits/modules (printed or Electronic)*2	34 (3.6)	41 (2.5)	46 (3.8)
State, county, district, or diocese-developed units or lessons	31 (3.1)	36 (1.8)	42 (3.3)
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)	27 (2.9)	36 (2.2)	34 (2.2)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	20 (2.7)	24 (1.5)	22 (2.7)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)	8 (1.4)	11 (1.2)	11 (2.1)

*1 There is a statistically significant difference between classes in schools serving rural communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between classes in schools serving rural communities and those serving urban communities (two-tailed independent samples t-test, $p < 0.05$).

[a] Only science classes for which instructional materials are designated by the state, district, or diocese are included in these analyses.

Regardless of whether instructional materials had been designated for their class, teachers were asked how often instruction was based on various types of materials. Units or lessons developed by teachers were the most commonly used material, serving as the basis of instruction at least once a week in nearly two-thirds of classes across community types (see Table 3.13). Commercially published textbooks were also used at least once a week in about 40–50 percent of all classes. There are no differences by community type. This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 3.13
Science Classes Basing Instruction on Various Types of Instructional Materials at Least Once a Week, by Community Type†

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
Units or lessons you created (either by yourself or with others)	63 (2.9)	65 (1.7)	62 (3.2)
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	49 (2.4)	42 (1.7)	41 (2.9)
Units or lessons you collected from any other source (e.g., conferences, journals, colleagues, university or museum partners)	36 (2.6)	38 (1.4)	38 (3.2)
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)	34 (2.5)	38 (1.6)	37 (3.3)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	26 (1.7)	26 (1.5)	29 (3.2)
State, county, district, or diocese-developed units or lessons	20 (2.2)	26 (1.6)	26 (3.5)
Commercially published kits/modules (printed or electronic)	22 (2.1)	26 (1.7)	25 (2.4)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)	8 (1.0)	9 (0.9)	7 (1.1)

† There are no statistically significant differences among classes in schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

Teachers who used commercially published textbooks were asked to record the title, author, publication year, and ISBN of the textbook used most often in the class. As can be seen in Table 3.14, roughly 70 percent of classes that used textbooks, regardless of community type, used ones that were six or more years old. The 2018 data are not significantly different from the 2012 data.

Table 3.14
Age of Science Textbooks in 2018, by Community Type(t),†

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
6 or more years	72 (3.6)	74 (3.3)	69 (3.8)
5 or fewer years	28 (3.6)	26 (3.3)	31 (3.8)

(t) Trend item

† There is no statistically significant difference in the distribution among classes in schools serving different community types (Chi-square test of independence, $p \geq 0.05$).

Facilities and Resources

The 2018 NSSME+ included several questions about availability of computing resources. As can be seen in Table 3.15, schools across community types had similar access to each type of resource. Virtually all schools had school-wide Wi-Fi, and a large majority had laptop/tablet carts and access to computer labs. However, fewer than half of schools had a 1-to-1 initiative where every student was provided with a laptop or tablet. For the trend items, the 2018 data are not significantly different from the 2012 data.

Table 3.15
Schools With Various Computing Resources, by Community Type†

	PERCENT OF SCHOOLS		
	RURAL	SUBURBAN	URBAN
School-wide Wi-Fi	100 (0.4)	98 (1.0)	99 (1.0)
(t) Laptop/tablet carts available for teachers to use with their classes	83 (3.2)	87 (2.0)	86 (2.4)
(t) One or more computer labs available for teachers to schedule for their classes	76 (4.0)	72 (2.7)	63 (3.8)
A 1-to-1 initiative (every student is provided with a laptop or tablet)	45 (3.9)	38 (2.7)	33 (3.4)

† There are no statistically significant differences among schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

The survey also asked about classroom availability of instructional resources. As can be seen in Table 3.16, the majority of classes across community types had access to projection devices and balances. Microscopes were also commonly available across schools, but more likely to be available in rural schools than suburban schools (80 vs. 73 percent). For the trend items, the differences in the availability of these technologies by community type have not changed significantly since 2012.

Table 3.16
Availability[a] of Instructional Resources in Science Classes, by Community Type

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
Projection devices (e.g., Smartboard, document camera, LCD projector)	98 (1.1)	98 (0.6)	97 (1.2)
Balances (e.g., pan, triple beam, digital scale)	92 (1.5)	87 (1.6)	87 (2.0)
(t) Microscopes*	80 (2.6)	71 (1.9)	73 (3.1)
(t) Probes for collecting data (e.g., motion sensors, temperature probes)	60 (3.2)	54 (2.1)	58 (4.1)

(t) Trend item

* There is a statistically significant difference between classes in schools serving rural communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

a Includes only those teachers indicating the resource is always available in their classroom or available upon request.

Additionally, teachers were asked about the availability of laboratory facilities for science instruction (see Table 3.17). Most of these facilities were widely available across community types. However, faucets/sinks and lab tables were more likely to be available to classes in rural schools than classes in suburban schools (92 vs. 85 percent and 64 vs. 53 percent, respectively). The 2018 data are not significantly different from the 2012 data.

Table 3.17
Availability[a] of Laboratory Facilities in Science Classes, by Community Type

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
(t) Electric outlets	97 (1.0)	94 (1.0)	97 (1.0)
(t) Faucets and sinks*	92 (1.3)	85 (1.7)	88 (2.1)
(t) Gas for burners[b]	84 (4.7)	87 (2.0)	85 (3.0)
(t) Fume hoods[b]	83 (4.7)	84 (2.0)	76 (4.3)
(t) Lab tables*	64 (2.6)	53 (2.2)	59 (4.0)

(t) Trend item

* There is a statistically significant difference between classes in schools serving rural communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

a Includes only those science teachers indicating the resource is either located in the classroom or available in another room.

b These items were only asked if the teacher indicated that they teach a high school-level course.

The 2018 NSSME+ also collected information about school spending on science equipment, consumable supplies, and software. By dividing these amounts by school enrollment, per-pupil estimates were generated. As can be seen in Table 3.18, expenditures for science were not distributed equally across schools. Urban schools spent considerably less per pupil on science resources than rural schools ($2.06 per pupil vs. $4.06 per pupil). Adjusting for inflation, the 2018 data on spending are not significantly different from the 2012 data.

Table 3.18
Median School Spending Per Pupil on Science Equipment, Consumable Supplies, and Software, by Community Type(t)

	MEDIAN AMOUNT*
Rural	$4.06 (0.7)
Suburban	$3.25 (0.5)
Urban	$2.06 (0.6)

(t) Trend item

* There is a statistically significant difference between schools serving rural communities and those serving urban communities (Mood's median test, $p < 0.05$).

Teachers were asked about the adequacy of instructional resources they have available. Although modest percentages of teachers rated their resources as adequate, there were no differences by community type (see Table 3.19). The 2018 data are not significantly different from the 2012 data.

Table 3.19
Adequacy[a] of Resources for Science Instruction, by Community Type

	PERCENT OF CLASSES†		
	RURAL	SUBURBAN	URBAN
(t) Equipment (e.g., thermometers, magnifying glasses, microscopes, beakers, photogate timers, Bunsen burners)	54 (3.0)	51 (1.8)	54 (3.8)
(t) Instructional technology (e.g., calculators, computers, probes/sensors)	59 (2.9)	58 (2.1)	52 (4.1)
(t) Facilities (e.g., lab tables, electric outlets, faucets and sinks)	54 (2.9)	53 (1.8)	50 (3.6)
(t) Consumable supplies (e.g., chemicals, living organisms, batteries)	41 (2.8)	44 (1.8)	43 (3.7)

(t) Trend item

† There are no statistically significant differences among classes in schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

a Includes science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not adequate" to 5 "adequate."

These items were combined into a composite variable called Adequacy of Resources for Science Instruction. As shown in Table 3.20, classes across community types were taught by teachers with moderately positive views about the adequacy of resources available to them. Looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 3.20
Science Class Mean Scores for the Adequacy of Resources for Instruction Composite, by Community Type[(t),†]

	MEAN SCORE
Rural	62 (1.6)
Suburban	61 (1.0)
Urban	61 (2.5)

(t) Trend composite

† There are no statistically significant differences among classes in schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

Summary

Overall, differences among community types are minimal with regard to the distribution of material resources for science instruction. Most schools across all three community types had instructional materials designated for use by the district, but designated materials were more common in urban schools than in suburban and rural schools. Although commercially published textbooks were the most commonly designated type of science instructional material, teacher-created units or lessons were the most frequently used. When commercially published textbooks were used, more than two-thirds of classes used ones that were at least six years old.

Resources and laboratory facilities were generally equally available to students in rural, suburban, and urban settings. However, urban schools spent considerably less per pupil on science resources than rural schools. Modest percentages of teachers rated their resources as adequate across the three community types.

Because items about material resources were either added, removed, or substantially modified for the 2018 study, trend analyses were limited. When trend analyses were conducted, there were no significant changes since 2012.

Well-Prepared Teachers

Teachers are among the most important resources impacting students' opportunity to learn science concepts. The 2018 NSSME+ collected data on a number of indicators of teacher preparedness, including their years of teaching experience, content preparation, beliefs about teaching and learning, perceptions of preparedness to teach science content and use classroom pedagogies, and professional development experiences. The distribution of well-prepared teachers among schools in each community type is described in the following sections.

Teacher Characteristics and Preparation

Table 3.21 provides information about the characteristics of teachers of science classes. There are several commonalities across community types. For example, about three-fourths of classes at the secondary level, across community types, were taught by teachers with a degree in science or science education. Similarly, over three-fourths of classes at the elementary and middle school levels level were taught by teachers who had completed the majority of NSTA recommended courses. Fewer than one-quarter of classes in each school setting were taught by teachers from historically underrepresented race/ethnicity groups. However, classes in urban schools were significantly more likely to be taught by teachers from these groups than classes in suburban or rural schools (24, 15, and 8 percent, respectively).

Table 3.21
Teacher Characteristics, by Community Type

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
(t) Secondary teacher with a degree in science or science education	74 (3.4)	78 (1.8)	79 (3.2)
(t) Teacher completed all or all-but-one of the NSTA recommended courses[a]	76 (2.1)	71 (1.9)	76 (2.6)
(t) Secondary teacher with a degree or 3+ advanced courses in the subject	58 (3.2)	65 (1.9)	59 (3.7)
(t) Teacher has 0–5 years of experience teaching science	28 (2.2)	26 (1.5)	29 (2.7)
(t) Teacher from historically underrepresented race/ethnicity group*	8 (2.1)	15 (1.3)	24 (3.3)
Teacher with job experience in science or engineering	17 (2.2)	16 (1.3)	18 (2.3)

(t) Trend item

* There are statistically significant differences among classes in schools serving each of the community types (two-tailed independent samples t-test, $p < 0.05$).

[a] The NSTA only has recommended courses for elementary and middle school grades teachers; high school teachers are not included.

Teacher Pedagogical Beliefs

Because beliefs are important mediators of behaviors, teachers were asked about their beliefs regarding effective teaching and learning (see Table 3.22). In 2018, teachers held a number of reform-oriented beliefs, regardless of school poverty level. For example, the vast majority of classes in all three community types were taught by teachers who agreed that: (1) they should ask students to support their conclusions about a science concept with evidence; (2) students should learn science by doing science; and (3) students learn best when instruction is connected to their everyday lives. However, teachers of classes across community types also agreed with statements associated with traditional beliefs. For example, 70–75 percent of classes were taught by teachers who agreed that at the beginning of instruction on a science idea, students should be provided with definitions for new scientific vocabulary that will be used. Over half also agreed that hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned. The 2018 data are not significantly different from the 2012 data.

Table 3.22
Science Classes in Which Teachers Agreed[a] With Various Statements About Teaching and Learning, by Community Type[†]

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
Reform-Oriented Beliefs			
Teachers should ask students to support their conclusions about a science concept with evidence.	96 (0.9)	96 (1.0)	97 (0.9)
Students should learn science by doing science (e.g., developing scientific questions; designing and conducting investigations; analyzing data; developing models, explanations, and scientific arguments).	93 (1.9)	95 (0.8)	96 (1.1)
Students learn best when instruction is connected to their everyday lives.	97 (0.8)	96 (0.8)	95 (1.1)
Most class periods should provide opportunities for students to apply scientific ideas to real-world contexts.	93 (2.1)	92 (1.1)	94 (1.2)
(t) Most class periods should provide opportunities for students to share their thinking and reasoning.	92 (2.1)	95 (0.6)	93 (1.4)
(t) It is better for science instruction to focus on ideas in depth, even if that means covering fewer topics.	75 (2.7)	77 (1.7)	75 (2.9)
Traditional Beliefs			
(t) At the beginning of instruction on a science idea, students should be provided with definitions for new scientific vocabulary that will be used.	70 (2.8)	70 (1.7)	75 (4.1)
(t) Hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned.	55 (2.7)	54 (1.9)	53 (3.3)
(t) Students learn science best in classes with students of similar abilities.	43 (2.7)	40 (1.9)	37 (3.2)
(t) Teachers should explain an idea to students before having them consider evidence that relates to the idea.	32 (2.9)	34 (1.8)	30 (2.7)

(t) Trend item

† There are no statistically significant differences among classes in schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

a Includes teachers indicating "strongly agree" or "agree" on a five-point scale ranging from 1 "strongly disagree" to 5 "strongly agree."

These items were combined into two composite variables: Reform-Oriented Teaching Beliefs and Traditional Teaching Beliefs. As can be seen in Table 3.23, although teachers across community types held fairly strong reform-oriented beliefs, traditional beliefs were also quite common. However, there are no differences in beliefs by community type. The 2018 data for Traditional Teaching Beliefs composite are not significantly different from the 2012 data.[21]

[21] Too few of the items in the 2018 Reform-Oriented Beliefs composite were also asked in 2012 to allow for a comparable composite to be created to examine trend over time.

Table 3.23
Science Class Mean Scores for Teachers' Beliefs About Teaching and Learning Composites, by Community Type†

	MEAN SCORE		
	RURAL	SUBURBAN	URBAN
Reform-Oriented Teaching Beliefs	85 (0.9)	87 (0.4)	87 (0.9)
(t) Traditional Teaching Beliefs[a]	57 (1.2)	56 (0.8)	55 (2.0)

(t) Trend composite

† There are no statistically significant differences among classes in schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

a This composite variable was not originally computed for the 2012 study. To allow for comparisons across time, it was computed for 2012 using the 2018 definition.

Teachers' Perceptions of Preparedness

The 2018 NSSME+ asked elementary teachers how well prepared they felt to teach each of a number of science topics at their assigned grade level. As shown in Table 3.24, although there are differences in teachers' perceptions of preparedness among the topics, community type is not a significant predictor. Looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 3.24
Elementary Classes in Which Teachers Considered Themselves Very Well Prepared to Teach Various Science Topics, by Community Type

	MEAN SCORE†		
	RURAL	SUBURBAN	URBAN
(t) Life Science	26 (3.5)	26 (2.3)	26 (4.5)
(t) Physical Science	16 (3.0)	14 (1.5)	20 (5.5)
(t) Earth/space Science	21 (3.5)	23 (2.0)	17 (3.0)
(t) Engineering	4 (1.5)	3 (1.3)	9 (5.9)

(t) Trend item

† There are no statistically significant differences among classes in schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

At the secondary level, there were some differences in the percentages of classes taught by teachers considering themselves very well prepared to teach various topics, each in favor of suburban schools (see Table 3.25). Classes in rural schools were less likely than classes in suburban schools to be taught by teachers who felt very well prepared to teach about Earth's features and physical processes (37 vs. 50 percent). Classes in urban schools were less likely than classes in suburban schools to be taught by teachers who felt very well prepared to teach about genetics (50 vs. 63 percent); elements, compounds, and mixtures (54 vs. 70 percent); and chemical bonding, equations, nomenclature, and reactions (42 vs. 55 percent). Further, classes in rural and urban schools were less likely than classes in suburban schools to be taught by teachers who felt very well prepared to teach about properties of solutions (42, 40, and 55 percent, respectively).

Table 3.25
Secondary Science Classes in Which Teachers Considered Themselves Very Well Prepared to Teach Each of a Number of Topics,[a] by Community Type

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
Earth/Space Science			
(t) Earth's features and physical processes*1	37 (4.9)	53 (3.5)	50 (5.2)
(t) The solar system and the universe	32 (4.6)	42 (2.7)	43 (5.6)
(t) Climate and weather	32 (4.8)	40 (3.4)	34 (4.6)
Biology/Life Science			
(t) Structures and functions of organisms	59 (4.3)	68 (2.6)	64 (3.8)
(t) Ecology/ecosystems	56 (4.3)	61 (3.3)	62 (4.0)
(t) Cell biology	57 (4.1)	67 (2.5)	61 (3.8)
(t) Genetics*2	55 (4.6)	63 (2.8)	50 (3.7)
(t) Evolution	43 (4.4)	56 (2.7)	49 (3.8)
Chemistry			
(t) States, classes, and properties of matter	63 (4.8)	74 (2.3)	65 (4.6)
(t) Atomic structure	57 (4.2)	68 (2.4)	62 (4.9)
(t) The periodic table	63 (4.8)	68 (2.8)	57 (5.1)
(t) Elements, compounds, and mixtures*2	61 (4.5)	70 (2.5)	54 (4.3)
(t) Chemical bonding, equations, nomenclature, and reactions*2	49 (5.0)	55 (2.4)	42 (3.4)
(t) Properties of solutions*3	42 (4.1)	55 (2.2)	40 (4.2)
Physics			
(t) Forces and motion	44 (4.1)	56 (2.8)	57 (4.3)
(t) Energy transfers, transformations, and conservation	45 (4.1)	53 (2.6)	51 (4.4)
(t) Properties and behaviors of waves	27 (3.3)	35 (2.5)	32 (3.8)
(t) Electricity and magnetism	22 (3.7)	30 (2.6)	28 (3.8)
(t) Modern physics	7 (2.3)	15 (2.1)	9 (2.3)
(t) **Environmental and Resource Issues** (e.g., land and water use, energy resources and consumption, sources and impacts of pollution)	39 (5.7)	42 (3.1)	39 (5.8)

(t) Trend item

*1 There is a statistically significant difference between classes in schools serving rural communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

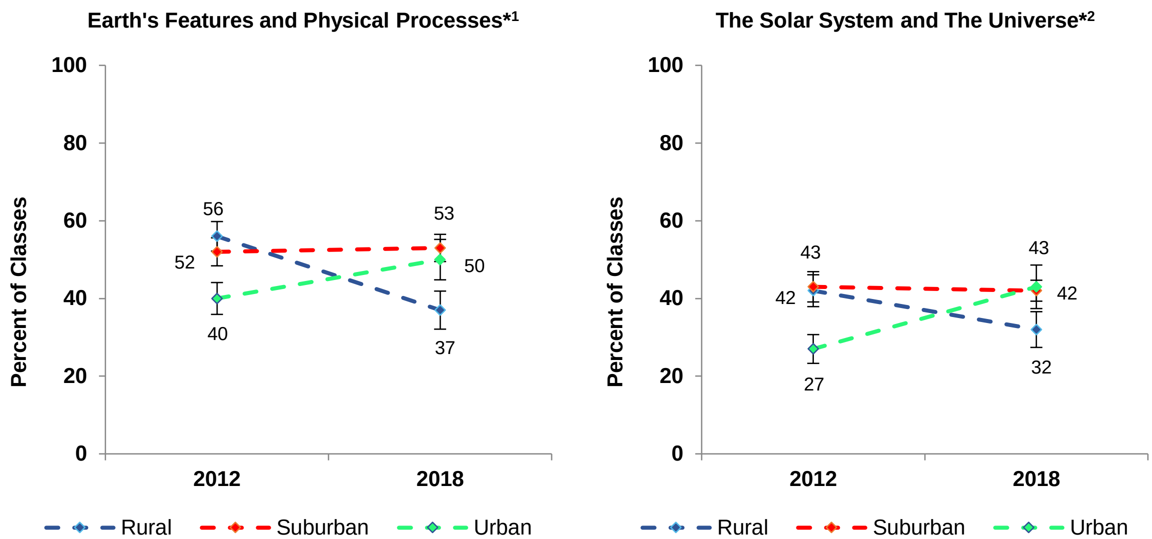
*2 There is a statistically significant difference between classes in schools serving urban communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

*3 There is a statistically significant difference between classes in schools serving suburban communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

a Each secondary science teacher was asked about one set of science topics based on the discipline of his/her randomly selected class.

There are a number of changes over time among community types in teachers' perceptions of their preparedness to teach science concepts. In Earth/space science, the gap in teachers' feelings of preparedness to teach about Earth's features and physical processes has: (1) widened between classes in rural and suburban schools and (2) reversed between classes in rural and urban schools (see Figure 3.2). These changes are likely due to decreased feelings of preparedness to teach this topic by teachers in rural schools from 2012 to 2018 (from 56 to 37 percent). There is also a difference over time between rural and urban schools in teachers' preparedness to teach about the solar system and the universe, with the percentage of classes taught by teachers feeling well prepared decreasing in rural schools (from 42 to 32 percent) and increasing in urban schools (from 27 to 43 percent).

Change Over Time:
Science Content Preparedness: Earth/Space Science



*1 There is a statistically signiificant difference between 2012 and 2018 in the magnitude of the gap between classes in schools serving rural communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes in schools serving rural communities and those serving urban communities (two-tailed independent samples t-test, $p < 0.05$).

Figure 3.2

In biology, there was a significant change over time between classes in urban and suburban schools related to teachers' feelings of preparedness to teach evolution (see Figure 3.3). In 2012, 51 percent of classes in urban schools and 41 percent of classes in suburban were taught by teachers who felt well prepared to teach evolution, compared to 49 and 56 percent of classes, respectively, in 2018.

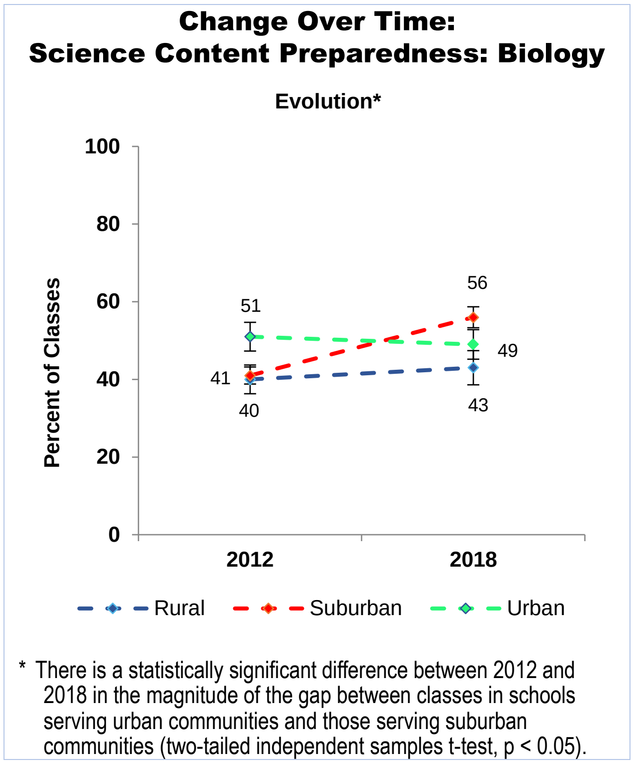
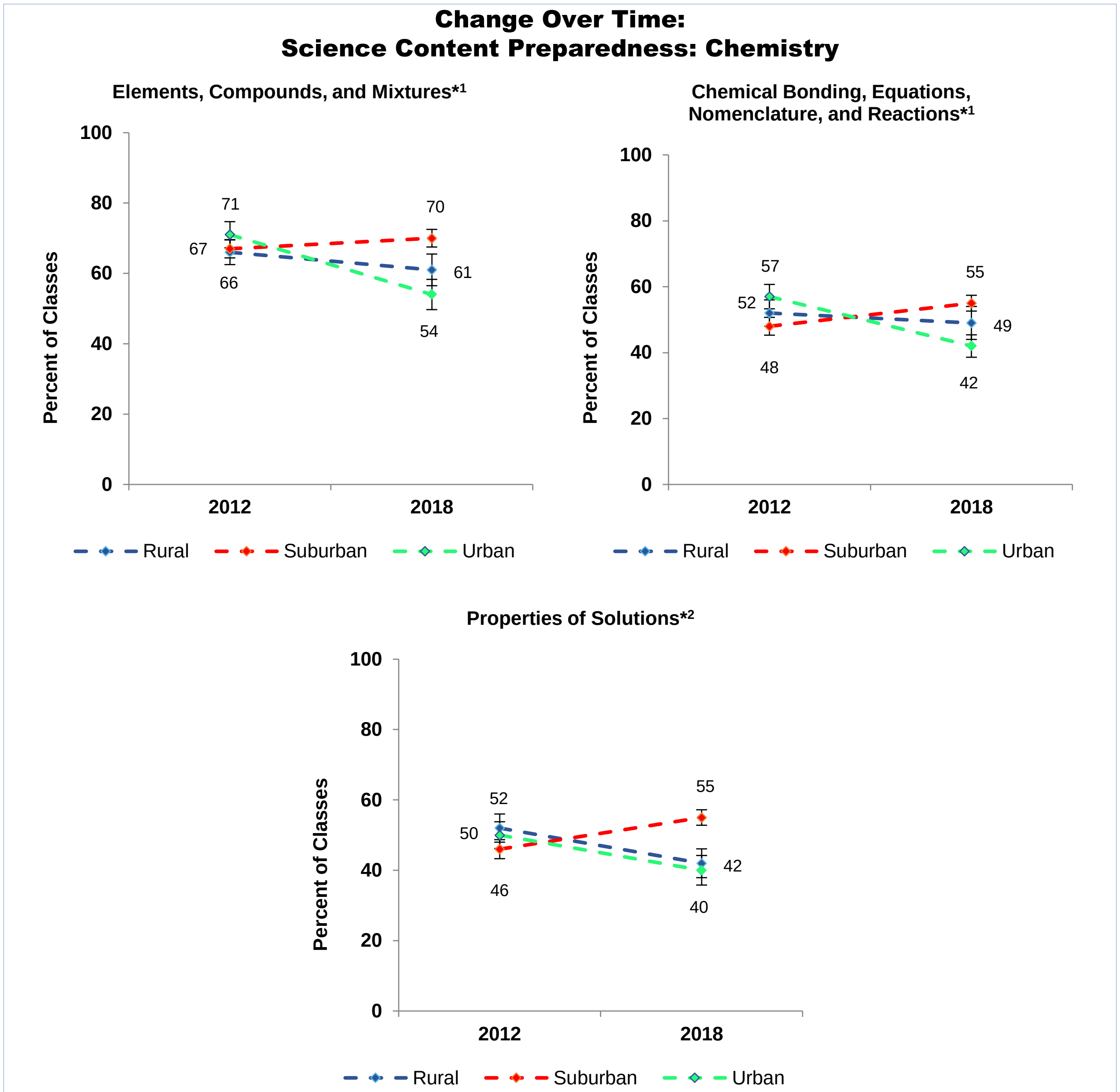


Figure 3.3

As can be seen in Figure 3.4, there were differences over time between classes in urban and suburban schools related to teachers' feelings of preparedness to teach about (1) elements, compounds, and mixtures and (2) chemical bonding, equations, nomenclature, and reactions, each in favor of classes in suburban schools. Further, there is a significant difference in the magnitude of the gap between classes in suburban schools and classes in urban and rural schools taught by teachers who felt well prepared to teach about properties of solutions, decreasing from 2012 to 2018 in urban and rural schools and increasing in suburban schools.



*1 There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes in schools serving urban communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes in schools serving suburban communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

Figure 3.4

In terms of engineering, few science classes at the secondary level were taught by teachers who considered themselves very well prepared in this area, regardless of community type (see Table 3.26). Teachers of classes in urban schools were less likely than those in suburban schools to feel well prepared to teach about optimizing design solutions (5 vs. 9 percent). This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 3.26
Secondary Science Classes in Which Teachers Considered Themselves Very Well Prepared to Teach Each of a Number of Engineering Topics, by Community Type

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
Developing possible solutions	10 (1.7)	11 (1.0)	11 (2.1)
Defining engineering problems	8 (1.6)	10 (0.9)	8 (1.3)
Optimizing design solutions*	8 (1.6)	9 (0.9)	5 (0.9)

* There is a statistically significant difference between classes in schools serving urban communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

The survey also asked teachers two series of items focused on their preparedness for a number of tasks associated with instruction. First, they were asked how well prepared they felt to use a number of student-centered pedagogies, including encouraging participation of all students and differentiating their instruction to meet learners' needs. Second, they were asked how well prepared they felt to carry out a number of tasks related to monitoring and addressing student thinking in their most recent unit. As can be seen in Table 3.27, there are no statistically significant differences among classes in rural, suburban, and urban settings. However, only modest percentages of teachers felt very well prepared for any of these instructional tasks. For example, just over one-third of all classes were taught by teachers who considered themselves very well prepared to: (1) use formative assessment to monitor student learning, (2) develop students' conceptual understanding, (3) encourage students' interest in science and/or engineering, and (4) encourage participation of all students in science and/or engineering. Additionally, small percentages of classes were taught by teachers who considered themselves very well prepared to incorporate students cultural backgrounds into science instruction. For the one trend item, there is no significant difference over time.

Table 3.27
Science Classes in Which Teachers Considered Themselves Very Well Prepared for Each of a Number of Tasks, by Community Type†

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
Use formative assessment to monitor student learning	37 (1.8)	42 (1.6)	41 (3.4)
Develop students' conceptual understanding	37 (1.9)	38 (1.5)	39 (2.7)
(t) Encourage students' interest in science and/or engineering	36 (1.8)	36 (1.5)	37 (2.8)
Encourage participation of all students in science and/or engineering	37 (2.2)	39 (1.6)	36 (2.9)
Differentiate science instruction to meet the needs of diverse learners	25 (2.0)	27 (1.4)	31 (2.8)
Develop students' abilities to do science (e.g., develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)	31 (2.3)	32 (1.5)	27 (2.5)
Provide science instruction that is based on students' ideas	19 (1.7)	18 (1.1)	20 (3.3)
Develop students' awareness of STEM careers	12 (1.3)	15 (0.9)	19 (3.0)
Incorporate students' cultural backgrounds into science instruction	15 (1.3)	13 (1.1)	17 (1.7)

(t) Trend item

† There are no statistically significant differences among classes in schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

Table 3.28 shows the percentage of science classes taught by teachers who felt very well prepared for each a number of tasks related to monitoring and addressing student thinking within a particular unit in a designated class. There are no significant differences among classes based on community type. Teachers in roughly 40–50 percent of classes, regardless of community type, felt very well prepared to assess student understanding at the conclusion of the unit, monitor student understanding during the unit, and implement the instructional materials to be used during the unit. The 2018 data are not significantly different from the 2012 data.

Table 3.28
Science Classes in Which Teachers Felt Very Well Prepared for Various Tasks in the Most Recent Unit, by Community Type†

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
(t) Assess student understanding at the conclusion of this unit	48 (3.0)	44 (1.3)	43 (2.8)
(t) Monitor student understanding during this unit	44 (2.7)	42 (1.6)	40 (2.7)
(t) Implement the instructional materials to be used during this unit	41 (2.4)	41 (1.6)	38 (2.7)
(t) Find out what students thought or already knew about the key science ideas	32 (2.3)	35 (1.3)	37 (3.9)
(t) Anticipate difficulties that students may have with particular science ideas and procedures in this unit	29 (2.0)	33 (1.4)	31 (2.8)

(t) Trend item

† There are no statistically significant differences among classes in schools serving different community types (two-tailed independent samples t-test, p ≥ 0.05).

The items in Tables 3.25–3.28 were used to create four composite variables: Perceptions of Content Preparedness, Perceptions of Preparedness to Teach Engineering, Perceptions of Pedagogical Preparedness, and Perceptions of Preparedness to Implement Instruction in a Particular Unit. As can be seen in Table 3.29, there are no differences by community type on any of these composites. The mean scores suggest that teachers, on average, felt only moderately well prepared to teach science content and implement instruction in a particular unit. Further, the low composite scores indicate that teachers generally do not feel well prepared to teach engineering. The 2018 data for the Perceptions of Content Preparedness and Perceptions of Preparedness to Implement Instruction in a Particular Unit composites are not significantly different from the 2012 data.[22]

[22] Too few of the items in the 2018 version of the Perceptions of Pedagogical Preparedness composite were also asked in 2012 to allow for a comparable composite to be created to examine trends over time. The Perceptions of Preparedness to Teach Engineering composite is new to the 2018 NSSME+, thus, trend data are not available to report.

Table 3.29
Science Class Mean Scores for Teachers' Perceptions of Preparedness Composites, by Community Type†

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
(t) Perceptions of Content Preparedness[a]	65 (1.0)	65 (0.9)	64 (1.6)
Perceptions of Preparedness to Teach Engineering	34 (1.8)	39 (1.0)	38 (1.6)
Perceptions of Pedagogical Preparedness	63 (1.0)	64 (0.6)	65 (1.4)
(t) Perceptions of Preparedness to Implement Instruction in Particular Unit	75 (1.1)	74 (0.7)	73 (1.2)

(t) Trend composite

† There are no statistically significant differences among classes in schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed for 2018 using the 2012 definition. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Teacher Professional Development

All professionals, including science teachers, need opportunities to keep up with advances in their field. The 2018 NSSME+ collected data on teachers' participation in professional development, including duration and characteristics of the experiences.

Regardless of community type, teachers of a large majority of classes participated in science-focused professional development in the previous three years (see Table 3.30). However, teachers of classes in rural schools were less likely to participate in professional development than teachers of classes in urban schools (65 vs. 76 percent). Further, only about 2 in 10 classes were taught by teachers with more than 35 hours of professional development in that timeframe, suggesting that most science teachers are not getting substantial opportunities to hone their skills. The 2018 data are not significantly different from the data in 2012.

Table 3.30
Professional Development Experiences of Teachers of Science Classes, by Community Type

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
(t) Teacher has had PD in the previous three years*	65 (2.4)	71 (1.7)	76 (2.7)
(t) Teacher has had more than 35 hours of PD in the previous three years	15 (1.5)	19 (1.0)	19 (2.0)

(t) Trend item

* There is a statistically significant difference between classes in schools serving rural communities and those serving urban communities (two-tailed independent samples t-test, $p < 0.05$).

As described in the FRL chapter, there is a consensus that professional development should provide teachers with opportunities to work with colleagues who face similar challenges, including other teachers from their school and those who have similar teaching assignments. Other recommendations include providing opportunities for teachers to engage in investigations, both to learn disciplinary content and to experience investigative learning; examine student work and other classroom artifacts for evidence of what students do and do not understand; and apply what they have learned in their classrooms and subsequently discuss how it went.[23] Accordingly, teachers who had participated in professional development in the previous three years were asked a series of additional questions about the nature of those experiences.

As can be seen in Table 3.31, for those teachers who attended professional development, these experiences were similar for teachers in all three community types. Roughly 50–60 percent of all classes were taught by teachers who attended professional development where they worked with other teachers from their school. However, this professional development characteristic was less common among teachers of classes in rural schools than teachers of classes in suburban schools (49 vs. 61 percent). About half of classes were taught by teachers who had opportunities during professional development to work closely with other teachers who taught the same grade and/or subject, whether or not they were from their school. There are no significant differences in these data over time.

Table 3.31
Science Classes in Which Teachers' Professional Development in the Previous Three Years Had Each of a Number of Characteristics to a Substantial Extent,[a] by Community Type

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
(t) Worked closely with other teachers from their school*	49 (3.5)	61 (2.1)	59 (3.9)
(t) Worked closely with other teachers who taught the same grade and/or subject whether or not they were from their school	48 (3.3)	55 (2.3)	48 (3.9)
Had opportunities to experience lessons, as their students would, from the textbook/ modules they use in their classroom	39 (3.2)	45 (2.1)	42 (3.8)
(t) Had opportunities to engage in science investigations/engineering design challenges	42 (3.6)	43 (2.2)	42 (3.6)
(t) Had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction)	34 (2.9)	35 (2.1)	35 (3.0)
(t) Had opportunities to apply what they learned to their classroom and then come back and talk about it as part of the professional development	35 (3.3)	39 (2.0)	34 (3.7)
Had opportunities to rehearse instructional practices during the professional development (i.e., try out, receive feedback, and reflect on those practices)	31 (3.6)	28 (1.7)	26 (2.8)

(t) Trend item

* There is a statistically significant difference between classes in schools serving rural communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent."

Further, teachers of classes across community types reported a number of similarities in the emphases of their professional development experiences (see Table 3.32). For example, roughly 40–50 percent of classes were taught by teachers who had professional development opportunities that gave heavy emphasis to: (1) deepening their understanding of how science is done, (2) differentiating science instruction to meet the needs of diverse learners, (3) deepening their own

[23] Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*(3), 181–199.

Elmore, R. F. (2002). *Bridging the gap between standards and achievement: The imperative for professional development in education.* Washington, DC: Albert Shanker Institute.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915–945.

content knowledge, and (4) monitoring student understanding during science instruction. Only two differences in professional development emphasis are evident by community type. Teachers of classes in rural schools were less likely than teachers of classes in suburban schools to have had professional development that gave heavy emphasis to learning how to provide science instruction that integrates engineering, mathematics, and/or computer science (32 vs. 41 percent). Similarly, teachers of classes in rural schools were less likely than teachers of classes in suburban and urban schools to have had professional development that heavily emphasized learning about difficulties that students may have with particular science ideas (26, 36, and 35 percent, respectively).

Table 3.32
Science ClassesTaught by Teachers Whose Professional Development in the Previous Three Years Gave Heavy Emphasis[a] to Various Areas, by Community Type

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
Deepening their understanding of how science is done (e.g., developing scientific questions, developing and using models, engaging in argumentation)	44 (3.5)	51 (2.0)	51 (3.8)
Differentiating science instruction to meet the needs of diverse learners	38 (3.2)	44 (1.9)	45 (3.8)
(t) Deepening their own science content knowledge	44 (3.4)	47 (2.1)	43 (3.5)
(t) Monitoring student understanding during science instruction	41 (3.1)	49 (2.1)	41 (3.8)
Learning how to provide science instruction that integrates engineering, mathematics, and/or computer science*1	32 (2.9)	41 (2.4)	37 (3.9)
(t) Finding out what students think or already know prior to instruction on a topic	34 (3.1)	39 (2.2)	36 (3.6)
(t) Learning about difficulties that students may have with particular science ideas*2	26 (2.8)	36 (2.4)	35 (3.6)
(t) Implementing the science textbook/modules to be used in their classroom	28 (3.3)	33 (1.9)	31 (3.1)
Incorporating students' cultural backgrounds into science instruction	19 (2.8)	22 (1.7)	29 (3.7)
Deepening their understanding of how engineering is done (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)	22 (3.1)	29 (2.1)	22 (3.1)

(t) Trend item

*1 There is a statistically significant difference between classes in schools serving rural communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between classes in schools serving rural communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

a Includes science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent."

Over time, there was a change in the gap between classes in urban schools and those in suburban schools that were taught by teachers whose professional development heavily emphasized monitoring student understanding during science instruction (see Figure 3.5). The change appears to be due to a decreased emphasis on this task in professional development attended by teachers in urban schools from 2012 to 2018 (from 58 to 41 percent).

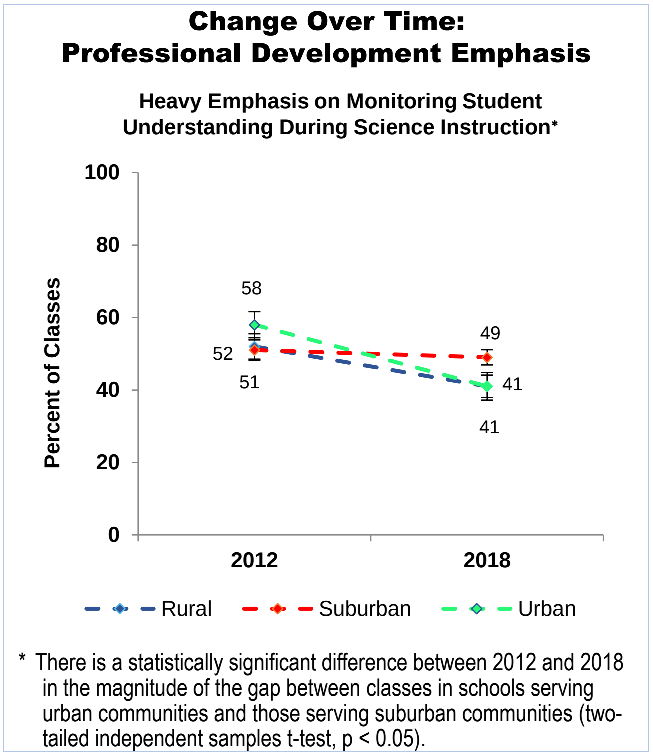


Figure 3.5

Survey items describing the characteristics and focus of teachers' professional development were combined into two composite variables: Extent Professional Development Aligns with Elements of Effective Professional Development and Extent Professional Development Supports Student-Centered Instruction. As can be seen in Table 3.33, class mean scores of roughly 50 indicate that teachers' professional development opportunities were only somewhat aligned with elements of effective professional development and somewhat supportive of student-centered instruction. Further, there is a significant difference between rural and suburban settings on the Extent Professional Development Supports Student-Centered Instruction composite (mean scores of 48 vs. 53). Looking over time, the 2018 Extent Professional Development Aligns with Elements of Effective Professional Development score is not significantly different from the 2012 score.[24]

[24] Too few of the items in the 2018 version of the Extent Professional Development Supports Student-Centered Instruction composite were also asked in 2012 to allow for a comparable composite to be created to examine trend over time.

Table 3.33
Science Class Mean Scores for Teachers' Professional Development Composites, by Community Type

	MEAN SCORE		
	RURAL	SUBURBAN	URBAN
(t) Extent Professional Development Aligns With Elements of Effective Professional Development[a]	50 (1.6)	54 (0.9)	52 (1.4)
Extent Professional Development Supports Student-Centered Instruction*	48 (1.4)	53 (1.0)	51 (1.5)

(t) Trend composite

* There is a statistically significant difference between classes in schools serving rural communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed using only the items in common at both time points. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Summary

Although there are many similarities in the distribution of well-prepared teachers among community types, there are also several notable differences. Most classes in rural, suburban, and urban schools were taught by teachers who had completed the majority of NSTA-recommended courses (elementary and secondary grades) or had a degree in science or science education (secondary grades). About 30 percent of classes across community types were taught by inexperienced teachers. However, classes in urban schools were also more likely than those in suburban and rural schools to be taught by teachers from race/ethnicity groups historically underrepresented in STEM.

Teachers across community types held strong reform-oriented beliefs (e.g., teachers should ask students to support their conclusions about a science concept with evidence, students should learn science by doing science). Interestingly, they also held relatively strong traditional beliefs, (e.g., students should be provided with definitions for new science vocabulary at the beginning of a unit, hands-on/laboratory activities should be used primarily to reinforce a science idea already learned).

Regardless of school community type, teachers generally felt well prepared to teach science topics appropriate for their grade level. However, there were some differences at the secondary level, each in favor of suburban schools. Teachers' perceptions of preparedness to use student-centered pedagogies and implement tasks related to monitoring and addressing student thinking in their most recent science unit were similar among classes across community types.

Further, there were a number of similarities among schools with regard to teachers' professional development experiences. A majority of science classes were taught by teachers who participated in science-focused professional development in the previous three years, although teachers of classes in rural schools were less likely to have participated in professional development than teachers of classes in urban schools. Teachers of classes across community types also pointed to similar characteristics and emphasis of their professional development experiences.

Similar to other sections of this report, trend analyses were conducted to look for changes over time. There were several significant changes since 2012 related to teachers' science content preparedness in Earth/space science, biology, and chemistry, which usually disadvantaged students in rural or urban schools. In addition, the gap between classes in urban and suburban schools taught by teachers whose professional development heavily emphasized monitoring student understanding during science instruction reversed from 2012 to 2018, favoring students in suburban schools.

Supportive Context for Learning

The 2018 NSSME+ collected information on a number of contextual factors that affect student opportunity to learn science, including professional development opportunities offered by schools and districts (i.e., workshops, teacher study groups, and formal induction programs). The study also asked about science programs and practices to enhance students' interest in science and factors that promote and inhibit effective science instruction in the school, such as administrator and community support. This section presents these data, highlighting the similarities and differences among rural, suburban, and urban schools.

Locally Offered Professional Development

School representatives were asked whether science-focused professional development workshops were offered by their school and/or district in the past three years. As can been seen in Table 3.34, rural schools were less likely than suburban or urban schools to have locally offered workshops (37, 53, and 59 percent, respectively). Further, urban schools were more likely than suburban or rural schools to offer study groups (36, 40, and 32 percent, respectively). One-on-one coaching was equally likely to be offered in all three school settings. When looking at trends, the 2018 data are not significantly different from the 2012 data.

Table 3.34
Types of Locally Offered Science Professional Development Available to Teachers, by Community Type

	PERCENT OF SCHOOLS		
	RURAL	SUBURBAN	URBAN
(t) Workshops*1	37 (4.4)	53 (2.8)	59 (4.6)
(t) One-on-one coaching	20 (3.9)	27 (2.5)	38 (4.5)
(t) Study groups*2	32 (3.9)	40 (2.6)	36 (3.5)

(t) Trend item

*1 There is a statistically significant difference between schools serving rural communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between schools serving urban communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

Science program representatives who indicated that workshops were offered locally in the previous three years were asked about the extent to which they emphasized each of a number of areas. As can be seen in Table 3.35, locally offered workshops in all three community types had a number of similar emphases. For example, about 50–70 of schools offered workshops with a substantial emphasis on deepening teachers' understanding of state science/engineering standards, deepening teachers' understanding of how science is done, deepening teachers' understanding of science concepts, and how to engage students in doing science. For the trend items, the 2018 data are not significantly different from the 2012 data.

Table 3.35
Locally Offered Science Professional Development Workshops in the Previous Three Years With a Substantial Emphasis[a] in Each of a Number of Areas, by Community Type[†]

	PERCENT OF SCHOOLS		
	RURAL	SUBURBAN	URBAN
(t) Deepening teachers' understanding of the state science/engineering standards	63 (7.8)	72 (3.8)	59 (5.5)
Deepening teachers' understanding of how science is done (e.g., developing scientific questions, developing and using models, engaging in argumentation)	54 (8.0)	60 (3.7)	59 (5.5)
(t) Deepening teachers' understanding of science concepts	55 (7.8)	59 (4.3)	56 (5.9)
How to engage students in doing science (e.g., developing scientific questions, developing and using models, engaging in argumentation)	52 (8.7)	54 (3.8)	55 (5.5)
(t) How to use technology in science/engineering instruction	42 (7.8)	48 (3.9)	52 (6.4)
(t) Deepening teachers' understanding of how students think about various science ideas	36 (7.7)	48 (4.6)	50 (5.9)
Deepening teachers' understanding of how engineering is done (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)	35 (8.0)	47 (4.8)	47 (6.0)
(t) How to use particular science/engineering instructional materials (e.g., textbooks or modules)	35 (7.6)	51 (4.8)	43 (5.9)
(t) How to monitor student understanding during science instruction	29 (6.8)	41 (4.0)	43 (5.6)
How to incorporate real-world issues (e.g., current events, community concerns) into science instruction	41 (8.3)	35 (3.7)	40 (5.5)
How to integrate science, engineering, mathematics, and/or computer science	31 (6.5)	37 (4.6)	38 (5.5)
(t) How to adapt science instruction to address student misconceptions	29 (7.0)	36 (3.9)	37 (5.7)
How to engage students in doing engineering (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)	36 (8.1)	38 (4.7)	36 (5.3)
How to connect instruction to science/engineering career opportunities	32 (6.5)	33 (4.1)	33 (5.8)
How to differentiate science instruction to meet the needs of diverse learners	31 (7.1)	26 (3.8)	29 (4.9)
How to develop students' confidence that they can successfully pursue careers in science/engineering	21 (6.6)	28 (3.6)	23 (4.8)
How to incorporate students' cultural backgrounds into science instruction	15 (5.0)	16 (3.2)	18 (4.5)

(t) Trend item

† There are no statistically significant differences among schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

a Includes schools indicating 4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent."

When teacher study groups were offered locally in the previous three years, representatives were asked about the topics emphasized in those groups. As can be seen in Table 3.36, deepening teachers' understanding of the state science/engineering standards, how to engage students in doing science, and how to use technology in science/engineering instruction were substantially emphasized in 40–70 percent of schools across community types.

However, there are also several differences when comparing rural schools to their suburban and urban counterparts. For example, study groups in rural schools were less likely than study groups in suburban and rural schools to emphasize how to monitor student understanding during science/ engineering instruction (29, 46, and 54 percent, respectively) and deepening teachers' understanding of science concepts (22, 47, and 43 percent, respectively). Study groups in rural schools were also less likely than study groups in suburban schools to emphasize deepening teachers' understanding of how science is done (31 vs. 53 percent) and deepening teachers' understanding of how engineering is done (20 vs. 39 percent). The 2018 data are not significantly different from the 2012 data.

Table 3.36
Locally Offered Science Teacher Study Groups in the Previous Three Years With a Substantial Emphasis[a] in Each of a Number of Areas, by Community Type

	PERCENT OF SCHOOLS		
	RURAL	SUBURBAN	URBAN
(t) Deepening teachers' understanding of the state science standards	59 (7.1)	67 (4.3)	69 (5.2)
How to engage students in doing science (e.g., developing scientific questions, developing and using models, engaging in argumentation)	44 (7.1)	61 (4.0)	58 (5.3)
(t) How to monitor student understanding during science/engineering instruction*1	29 (4.7)	46 (4.2)	54 (6.1)
(t) How to use technology in science/engineering instruction	40 (6.7)	49 (5.3)	50 (5.8)
(t) How to use particular science/engineering instructional materials (e.g., textbooks or modules)	39 (6.9)	48 (4.6)	49 (5.6)
(t) Deepening teachers' understanding of how students think about various science ideas	33 (6.2)	46 (4.1)	48 (6.4)
Deepening teachers' understanding of how science is done (e.g., developing scientific questions, developing and using models, engaging in argumentation)*2	31 (5.9)	53 (4.4)	45 (5.7)
(t) How to adapt science instruction to address student misconceptions	29 (5.8)	40 (4.4)	44 (6.0)
(t) Deepening teachers' understanding of science concepts*1	22 (6.0)	47 (4.3)	43 (5.5)
How to incorporate real-world issues (e.g., current events, community concerns) into science instruction	39 (6.6)	45 (3.7)	42 (5.6)
How to integrate science, engineering, mathematics, and/or computer science	35 (6.4)	39 (3.9)	39 (5.9)
How to engage students in doing engineering (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)	26 (6.6)	41 (4.3)	36 (5.2)
How to differentiate science instruction to meet the needs of diverse learners	36 (6.7)	40 (4.3)	36 (5.4)
Deepening teachers' understanding of how engineering is done (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)*2	20 (6.3)	39 (4.9)	33 (5.0)
How to develop students' confidence that they can successfully pursue careers in science/engineering	16 (5.0)	26 (4.1)	29 (6.1)
How to connect instruction to science/engineering career opportunities	25 (6.5)	27 (4.2)	27 (6.0)
How to incorporate students' cultural backgrounds into science instruction	12 (3.3)	21 (4.2)	17 (4.5)

(t) Trend item

*1 There is a statistically significant difference between schools serving rural communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between schools serving rural communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes schools indicating 4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent."

Science program representatives were also asked about services provided to teachers in need of special assistance. As can be seen in Table 3.37, there were no differences by community type in the availability of these services. Guidance from a formally designated mentor or coach was the most common service, provided in 30–45 percent of schools. Seminars, classes, and/or study groups were also offered in about a third of schools. There are no significant differences in these data over time.

Table 3.37
Services Provided to Teachers in Need of Special Assistance in Teaching, by Community Type†

	PERCENT OF SCHOOLS		
	RURAL	SUBURBAN	URBAN
(t) Guidance from a formally designated mentor or coach	30 (3.3)	37 (2.7)	45 (4.8)
(t) Seminars, classes, and/or study groups	27 (4.8)	29 (2.9)	30 (4.4)
(t) A higher level of supervision than for other teachers	19 (3.1)	18 (1.9)	27 (4.4)

(t) Trend item

† There are no statistically significant differences among schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

In 2018, the percentages of schools offering a formal teacher induction program were similar across community types, with about three-fourths of schools having such a program (see Table 3.38). About 3 in 10 schools, regardless of community type, had programs that lasted one year or less, and about 4 in 10 schools had programs that lasted two years or more. This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 3.38
Typical Duration of Formal Induction Programs, by Community Type†

	PERCENT OF SCHOOLS		
	RURAL	SUBURBAN	URBAN
No formal induction program	29 (4.0)	21 (2.5)	25 (3.7)
One year or less	34 (4.6)	35 (2.9)	30 (3.9)
Two years or more	36 (4.6)	44 (2.6)	45 (4.2)

† There are no statistically significant differences in the distribution among schools serving different community types (Chi-square test of independence, $p \geq 0.05$).

The research on effective induction programs also suggests a number of supports that are important for a program's success.[25] As can be seen in Table 3.39, large percentages of schools offered meetings to orient new teachers to school and district policies and practices, professional development opportunities on teaching in their subject, and formally assigned school-based mentor teachers as parts of their formal induction programs. Conversely, across community types, very few formal induction programs included a reduced number of teaching preps, reduced course load, or reduced class size. However, there are some differences when looking across community types. Urban and rural schools were less likely than suburban schools to offer meetings to orient new teachers to school and district policies and practices (84, 84, and 94 percent, respectively). Urban schools were also less likely than suburban or rural schools to offer formally assigned school-based mentors (78, 87, and 90 percent, respectively) and financial support to attend national, state, or local teacher conferences (15, 27, and 30 percent, respectively). Additionally, rural schools were less likely than suburban schools to offer common planning time with experienced teachers who teach the same subject or grade (60 vs. 70 percent) and less likely than urban schools to provide district-level or university-based mentors (23 vs. 37 percent).

[25] Ingersoll, R., & Strong, M. (2011). *The impact of induction and mentoring programs for beginning teachers: A critical review of the research.* Retrieved from https://repository.upenn.edu/gse_pubs/127.

Table 3.39
Supports Provided as Parts of Formal Induction Programs, by Community Type†

	PERCENT OF SCHOOLS[a]		
	RURAL	SUBURBAN	URBAN
A meeting to orient them to school district/diocese policies and practices*1	84 (3.3)	94 (1.4)	84 (3.9)
Professional development opportunities on teaching their subject	76 (4.3)	80 (2.2)	81 (3.6)
Formally assigned school-based mentor teachers*2	90 (3.1)	87 (1.9)	78 (3.3)
Common planning time with experienced teachers who teach the same subject or grade level*3	60 (4.6)	79 (2.4)	70 (4.7)
Release time to observe other teachers in their grade/subject area	66 (4.4)	73 (2.5)	66 (4.5)
Professional development opportunities on providing instruction that meets the needs of students from the cultural backgrounds represented in the school	40 (4.6)	46 (3.6)	53 (4.6)
District/Diocese-level or university-based mentors*4	23 (3.8)	28 (2.7)	37 (3.7)
Release time to attend national, state, or local teacher conferences	41 (4.8)	38 (3.1)	31 (3.7)
Financial support to attend national, state, or local teacher conferences*2	30 (4.4)	27 (2.9)	15 (2.6)
Supplemental funding for classroom supplies	14 (3.2)	13 (2.2)	14 (3.1)
Classroom aides/teaching assistants	14 (3.2)	13 (2.2)	14 (3.1)
Reduced number of teaching preps	3 (0.7)	4 (0.7)	7 (2.1)
Reduced course load	2 (1.2)	2 (1.1)	2 (1.2)
Reduced class size	1 (1.0)	1 (0.4)	1 (0.5)

*1 There is a statistically significant difference between schools serving suburban communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between schools serving urban communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

*3 There is a statistically significant difference between schools serving rural communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

*4 There is a statistically significant difference between schools serving rural communities and those serving urban communities (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes only those schools that provide a formal induction program.

Factors That Affect Instruction and Student Opportunity to Learn

The NSSME+ asked program representatives about instructional arrangements, course formats, and other practices that promote interest in science and support (or inhibit) effective science instruction. Table 3.40 shows the prevalence of various instructional arrangements for students in elementary self-contained classrooms. These data are similar across community types. For example, about 30 percent of schools pulled students in self-contained classes out for additional instruction in other content areas and roughly 10–20 percent provided instruction from a science specialist in addition to the regular classroom teacher. However, urban schools were more likely than suburban or rural schools to provide science instruction on a regular basis from someone outside of the school (9, 0, and 0 percent, respectively). When looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 3.40
Use of Various Instructional Arrangements in Elementary Schools, by Community Type

	PERCENT OF SCHOOLS[a]		
	RURAL	SUBURBAN	URBAN
(t) Students in self-contained classes are pulled out from science instruction for additional instruction in other content areas.	30 (6.1)	25 (4.1)	33 (6.2)
(t) Students in self-contained classes receive instruction from a district/diocese/school science specialist *in addition* to their regular teacher.	11 (2.8)	12 (3.0)	23 (4.6)
(t) Students in self-contained classes are pulled out for enrichment in science.	5 (3.4)	13 (2.9)	9 (2.9)
Students in self-contained classes receive science instruction on a regular basis from someone outside of the school/district/diocese (e.g., museum staff).*	0 (0.4)	0 --[b]	9 (3.9)
(t) Students in self-contained classes are pulled out for remedial instruction in science.	6 (2.3)	9 (3.2)	8 (3.6)
(t) Students in self-contained classes receive instruction from a district/diocese/school science specialist *instead of* their regular teacher.	5 (2.4)	10 (2.9)	5 (2.1)

(t) Trend item

* There is a statistically significant difference between classes in schools serving urban communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

a Item was only presented to program representatives whose schools had self-contained teachers.

b No program representatives in this community type selected this response option. Thus, it is not possible to calculate the standard error of this estimate.

At the high school level, the NSSME+ asked about a number of specific course-taking opportunities provided to students. As can be seen in Table 3.41, there are no differences by community type. Over 80 percent of high schools offered physics courses, and 40–60 percent offered opportunities for students to go to a college or university for science and/or engineering courses, access to virtual science and/or engineering courses offered by other schools/institutions, and concurrent college and high school credit/dual enrollment courses. When looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 3.41
Science Course-Taking Options in High Schools, by Community Type

	PERCENT OF SCHOOLS†		
	RURAL	SUBURBAN	URBAN
(t) Physics Courses are offered this school year or in alternating years, on or off site.	85 (5.7)	95 (2.1)	81 (6.3)
(t) Students can go to a college or university for science and/or engineering courses.	54 (6.6)	59 (3.8)	46 (5.9)
This school provides students access to virtual science and/or engineering courses offered by other schools/institutions.	43 (6.6)	39 (3.5)	42 (6.1)
(t) Concurrent college and high school credit/dual enrollment courses are offered this school year or in alternating years.	44 (6.4)	51 (4.7)	41 (5.8)
(t) Students can go to a Career and Technical Education center for science and/or engineering instruction.	39 (5.1)	42 (4.1)	40 (6.3)
(t) Students can go to another K–12 school for science and/or engineering courses.	13 (3.6)	15 (2.6)	23 (5.1)
This school provides its own science and/or engineering courses virtually.	10 (3.0)	14 (2.8)	22 (5.6)

(t) Trend item

† There are no statistically significant differences among schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

Program representatives were also asked to indicate which of several programs and practices their school employed to enhance student interest and/or achievement in science. As can be seen in Table 3.42, less than half of schools offered any of these programs or practices. Looking at differences among community types, rural schools were less likely than suburban or urban schools to hold family nights (23, 42, and 44 percent, respectively). Looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 3.42
School Programs/Practices to Enhance Students' Interest in Science, by Community Type

	PERCENT OF SCHOOLS		
	RURAL	SUBURBAN	URBAN
(t) After school help	47 (4.2)	44 (3.1)	46 (4.2)
(t) Science clubs	36 (3.8)	45 (3.4)	44 (4.9)
(t) Family nights*	23 (3.8)	42 (2.9)	44 (4.8)
(t) After-school programs for enrichment	28 (4.1)	36 (3.6)	40 (3.8)
(t) Engineering clubs	28 (3.8)	31 (2.6)	35 (4.1)
(t) Engineering competitions	32 (3.3)	32 (2.7)	29 (3.9)
(t) Science competitions	23 (3.2)	24 (2.1)	27 (3.9)

(t) Trend item

* There is a statistically significant difference between schools serving rural communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

Table 3.43 presents program representatives' views on factors that promote science instruction in schools. Overall, there are no significant differences in these factors among schools by community type. Representatives from about half of all schools rated school professional development policies, how science instructional resources are managed, and the importance the school places on science as factors promoting effective instruction. The 2018 data are not significantly different from the 2012 data.

Table 3.43
Factors Promoting Effective Science Instruction, by Community Type†

	PERCENT OF SCHOOLS		
	RURAL	SUBURBAN	URBAN
(t) The school/district/diocese science professional development policies and practices	46 (5.2)	53 (3.1)	56 (4.6)
(t) How science instructional resources are managed (e.g., distributing and refurbishing materials)	46 (4.4)	48 (3.7)	52 (4.8)
(t) The importance that the school places on science	52 (4.8)	51 (3.0)	51 (4.3)
(t) The amount of time provided by the school/district/diocese for teacher professional development in science	35 (4.4)	34 (2.8)	40 (4.2)
The amount of time provided by the school/district/diocese for teachers to share ideas about science instruction	28 (4.4)	40 (2.7)	37 (4.4)
(t) Other school and/or district/diocese initiatives	34 (4.0)	34 (3.2)	37 (4.3)

(t) Trend item

† There are no statistically significant differences among schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

These items were combined into a composite variable to look at the effects of these factors on science instruction more holistically. As can be seen in Table 3.44, schools across community types had similarly supportive contexts for science instruction. The 2018 data for this composite are not significantly different from the 2012 data.

Table 3.44
School Mean Scores for the Supportive Context for Science Instruction Composite,[a] by Community Type[(t)]

	MEAN SCORE†
Rural	73 (2.3)
Suburban	70 (1.6)
Urban	68 (2.7)

(t) Trend composite

† There are no statistically significant differences among schools serving different community types (two-tailed independent samples t-test, p ≥ 0.05).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed using only the items in common at both time points. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Program representatives were also asked to rate whether each of several factors was a problem for science instruction in their school. There is quite a bit of variation across community types in these ratings (see Table 3.45). For example, rural and urban schools were more likely than suburban schools to consider low student prior knowledge and skills (73, 75, and 60 percent, respectively) and low student interest in science (51, 41, and 29 percent, respectively) as problematic for science instruction. Urban schools were also more likely than rural schools to consider insufficient instructional time (70 vs. 54 percent) and inadequate teacher preparation to teach science (56 vs. 38 percent) as problematic. Additionally, urban schools were more likely than suburban schools to view inappropriate student behavior (55 v. 42 percent) and high student absenteeism (49 vs. 34 percent) as problematic. These data are not significantly different from the 2012 data.

Table 3.45
Science Program Representatives Viewing Each of a Number of Factors as a Problem[a] for Science Instruction in Their School, by Community Type

	PERCENT OF SCHOOLS		
	RURAL	SUBURBAN	URBAN
Low student prior knowledge and skills*1	73 (3.6)	60 (2.5)	75 (3.8)
(t) Insufficient instructional time to teach science*2	54 (4.3)	60 (3.0)	70 (3.6)
(t) Inadequate science-related professional development opportunities	70 (4.4)	70 (2.7)	68 (3.9)
(t) Inadequate materials for differentiating science instruction	61 (4.1)	64 (2.8)	66 (4.1)
(t) Inadequate funds for purchasing science equipment and supplies	61 (4.2)	58 (3.1)	62 (3.5)
(t) Lack of science facilities (e.g., lab tables, electric outlets, faucets and sinks in classrooms)	46 (4.1)	56 (3.3)	56 (4.4)
(t) Inadequate teacher preparation to teach science*2	38 (4.7)	49 (2.8)	56 (3.9)
(t) Inappropriate student behavior*3	42 (5.0)	42 (2.7)	55 (3.6)
(t) Lack of parent/guardian support and involvement	51 (4.4)	48 (2.6)	54 (4.4)
(t) Large class sizes	41 (4.2)	47 (2.8)	53 (4.3)
(t) High student absenteeism*3	45 (4.6)	34 (2.0)	49 (4.4)
Poor quality science textbooks/modules	48 (4.3)	50 (2.8)	43 (4.1)
High teacher turnover	28 (4.1)	30 (2.8)	43 (4.3)
(t) Lack of teacher interest in science	31 (3.8)	32 (2.5)	41 (4.9)
(t) Low student interest in science*1	51 (5.2)	29 (2.2)	41 (3.8)
(t) Lack of science textbooks/modules	46 (4.4)	45 (3.0)	39 (4.4)
(t) Community resistance to the teaching of "controversial" issues in science (e.g., evolution, climate change)	19 (3.7)	20 (2.5)	12 (3.1)

(t) Trend item

*1 There is a statistically significant difference between schools serving suburban communities and those serving other community types (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between schools serving rural communities and those serving urban communities (two-tailed independent samples t-test, $p < 0.05$).

*3 There is a statistically significant difference between schools serving urban communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

a Includes schools indicating "somewhat of a problem" or "serious problem" on a three-point scale from 1 "not a significant problem" to 3 "serious problem."

Three composite variables were created from these items: Extent to Which Student Issues are Problematic, Extent to Which a Lack of Resources is Problematic, and Extent to which Teacher Issues are Problematic. As can be seen in Table 3.46, urban schools were more likely than rural schools to consider teacher issues to be problematic (mean scores of 38 vs. 30) and more likely than suburban schools to consider student issues to be problematic (mean scores of 31 vs. 25). The 2018 Extent to Which Lack of Resources is Problematic and Extent to Which Student Issues Are Problematic composites are not significantly different from 2012.[26]

[26] The 2012 data did not support the creation of the Extent to Which Teacher Issues are Problematic composite; thus, trend data are not available to report.

Table 3.46
School Mean Scores for Factors Affecting Science Instruction Composites, by Community Type

	MEAN SCORE		
	RURAL	SUBURBAN	URBAN
Extent to Which Teacher Issues are Problematic*1	30 (2.2)	34 (1.6)	38 (2.3)
(t) Extent to Which a Lack of Resources is Problematic[a]	34 (2.2)	36 (1.6)	35 (2.4)
(t) Extent to Which Student Issues are Problematic*2,b	28 (1.8)	25 (1.1)	31 (1.7)

(t) Trend composite

*1 There is a statistically significant difference between schools serving rural communities and those serving urban communities (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between schools serving urban communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed for 2018 using the 2012 definition. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

[b] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed using only the items in common at both time points. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Teachers were also asked about factors that affect science instruction. As can be seen in Table 3.47, about two-thirds of classes, regardless of community type, were taught by teachers who rated students' motivation, interest, and effort in science; principal support; time for planning; and current state standards as promoters of effective science instruction. However, classes in urban schools were less likely than classes in rural schools to be taught by teachers rating the amount of time available for professional development as promoting effective science instruction (55 vs. 42 percent). Additionally, classes in rural schools were more likely than classes in suburban schools to be taught by teachers who rated teacher evaluation policies as promoting effective science instruction (46 vs. 36 percent). The 2018 data are not significantly different from the 2012 data.

Table 3.47
Factors Promoting[a] Effective Instruction in Science Classes, by Community Type

	PERCENT OF CLASSES		
	RURAL	SUBURBAN	URBAN
(t) Students' motivation, interest, and effort in science	65 (2.6)	69 (1.7)	67 (2.8)
(t) Principal support	66 (2.7)	66 (2.0)	67 (3.2)
(t) Amount of time for you to plan, individually and with colleagues	59 (3.1)	61 (2.1)	67 (3.1)
(t) Current state standards	63 (3.0)	61 (1.9)	66 (3.4)
Students' prior knowledge and skills	59 (2.4)	58 (1.9)	60 (3.1)
(t) College entrance requirements[b]	48 (4.9)	51 (3.0)	59 (4.8)
(t) Amount of time available for your professional development*1	42 (3.1)	47 (2.1)	55 (3.4)
(t) Pacing guides	55 (3.3)	53 (2.3)	52 (4.1)
Amount of instructional time devoted to science[c]	48 (4.3)	48 (3.5)	51 (5.6)
(t) Teacher evaluation policies*2	46 (3.0)	36 (2.3)	43 (4.0)
(t) Parent/guardian expectations and involvement	37 (2.9)	40 (2.0)	42 (3.0)
(t) State/district/diocese testing/accountability policies[d]	36 (2.9)	31 (1.6)	37 (3.6)
(t) Textbook/module selection policies	41 (3.4)	32 (2.2)	35 (3.3)

(t) Trend item

*1 There is a statistically significant difference between classes in schools serving rural communities and those serving urban communities (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between classes in schools serving rural communities and those serving suburban communities (two-tailed independent samples t-test, $p < 0.05$).

a Includes science teachers indicating 4 or 5 on a five-point scale ranging from 1 "inhibits effective instruction" to 5 "promotes effective instruction."

b This item was presented only to high school teachers.

c This item was presented only to elementary school teachers.

d This item was presented only to teachers in public and Catholic schools.

Three composites from these items were created to summarize the extent to which teachers see various factors supporting effective instruction: (1) Extent to Which School Support Promotes Effective Instruction; (2) Extent to Which the Policy Environment Promotes Effective Instruction; and (3) Extent to Which Stakeholders Promote Effective Instruction. As can be seen in Table 3.48, there are no differences in the composite mean scores by community type. When looking at trends, the 2018 data for the Extent to Which School Support Promotes Effective Instruction and Extent to Which the Policy Environment Promotes Effective Instruction composites are not significantly different from the 2012 data.[27]

[27] Too few items in the 2018 version of the Extent to Which Stakeholders Promote Effective Instruction composite were also asked in 2012; thus, trend data are not available to report.

Table 3.48
Science Class Mean Scores for Factors Affecting Instruction Composites, by Community Type†

	MEAN SCORE		
	RURAL	SUBURBAN	URBAN
(t) Extent to Which School Support Promotes Effective Instruction	63 (1.9)	64 (1.3)	68 (2.2)
Extent to Which Stakeholders Promote Effective Instruction	65 (1.3)	65 (1.1)	66 (2.0)
(t) Extent to Which the Policy Environment Promotes Effective Instruction[a]	64 (1.2)	61 (0.9)	63 (1.6)

(t) Trend composite

† There are no statistically significant differences among classes in schools serving different community types (two-tailed independent samples t-test, $p \geq 0.05$).

a This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed for 2012 using the 2018 definition.

Summary

There are both similarities and differences in the data about the supportiveness of school contexts for science learning among community types. In terms of school-level professional development offerings, science-focused workshops were the most common offering across community types. However, rural schools were less likely than suburban or urban schools to offer these workshops. Though study groups were less common overall, this form of professional development was more likely to be offered in urban schools than suburban and rural schools.

The emphasis of science-focused workshops was quite similar across community types. However, there were several differences in the emphasis of study groups, each of which disadvantage rural schools. For example, study groups in rural schools were less likely than those in suburban and urban schools to emphasize how to monitor student understanding and deepening teachers' understanding of science concepts. Additionally, an emphasis on deepening teachers' understanding of how science and engineering are done was more common in study groups in suburban schools than those in rural or urban schools.

There were few differences among community types in regard to the services provided to teachers in need of special assistance and those new to the profession. About three-fourths of schools offered formal teacher induction programs. However, teachers in urban schools were less likely than teachers in suburban or rural schools to have a formally assigned school-based mentor as part of the induction program.

The use of different instructional arrangements at the elementary level was similar in rural, suburban, and urban schools. There was also a great deal of consistency at the high school level in course-taking opportunities. Over 80 percent of all schools offered physics courses, and over 40 percent offered opportunities for students to go to a college or university for science and/or engineering courses.

Schools' use of programs and practices to enhance student interest and achievement in science was relatively consistent across community types, with large percentages of schools encouraging students to participate in science and/or engineering summer programs or camps. Program representatives' perceptions of factors that promote effective science instruction in schools were also similar across community types. Further, school climate was seen by teachers as moderately supportive of effective science instruction in all three community types. Over two-thirds of classes across community types were taught by teachers who rated students' motivation, interest, and effort in science and principal support as promotors of effective instruction. However, program representatives pointed to a number of factors as problematic for science instruction, including low student prior knowledge and skill, insufficient time to teach science, and inadequate science-related professional development opportunities.

Over time, the context for science instruction has been relatively consistent. There are no significant changes from 2012 to 2018 in the supportiveness of context for science instruction among community types.

Students from Race/Ethnicity Groups Historically Underrepresented in STEM

For this class-level factor, teachers were asked to respond to questions about a randomly selected science class. Each randomly selected class was classified into 1 of 4 categories based on the percentage of students in the class identified as being from race/ethnicity groups historically underrepresented in STEM. As can be seen in Table 4.1, classes in the lowest quartile had an average of only 3 percent of students from these groups, compared to 89 percent in the highest quartile. This chapter shows study data for classes in each quartile and highlights differences between classes in the lowest and highest quartiles.

Table 4.1
Average Percentage of Students From Race/Ethnicity Groups Historically Underrepresented in STEM(t)

	PERCENT HUS
Lowest Quartile	3 (0.1)
Second Quartile	16 (0.2)
Third Quartile	44 (0.6)
Highest Quartile	89 (0.6)

(t) Trend item

Nature of Science Instruction

The 2018 NSSEM+ collected a variety of data about science instruction, including time spent on science, course enrollment, and instructional objectives and activities. This section presents these data, highlighting similarities and differences between classes with the highest percentages of students from race/ethnicity groups historically underrepresented in STEM (high-HUS classes) and those containing the lowest percentages of students from these groups (low-HUS classes).

Time Spent on Various Subjects in Elementary Grades

Student opportunity to learn science is related to the amount of instructional time devoted to this subject. Table 4.2 shows the average number of minutes per day typically spent on science, reading/language arts, mathematics, and social studies in elementary grades self-contained classes that cover all four subjects. High-HUS classes spent more time on science instruction than low-HUS classes (23 vs. 17 minutes). However, time spent on science instruction in both high- and low-HUS classes was substantially less than time spent on reading/language arts or mathematics. When looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 4.2
Average Number of Minutes Per Day Spent Teaching Each Subject in Elementary Grades Self-Contained Classes, by HUS Quartile[a]

	NUMBER OF MINUTES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Reading/Language Arts	85 (2.8)	88 (2.4)	90 (2.8)	88 (2.7)
(t) Mathematics*	55 (1.5)	57 (1.4)	60 (1.9)	61 (1.8)
(t) Science*	17 (0.9)	19 (0.8)	19 (1.1)	23 (1.0)
(t) Social Studies*	16 (0.8)	16 (0.7)	16 (0.8)	19 (0.8)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes only self-contained elementary teachers who indicated they teach reading, mathematics, science, and social studies to one class of students.

Course-Taking Opportunities in High School

The study also provides the opportunity to examine the percentage of students from race/ethnicity groups historically underrepresented in STEM in different types of high school science course. Despite making up almost half of all students in 2018, students from race/ethnicity groups historically underrepresented in STEM made up 43 percent of the enrollment in non-college prep science classes, with a pattern of decreasing enrollment in more advanced science classes (see Table 4.3). Similar patterns were seen in the 2012 data.

Table 4.3
Average Percentage of Historically Underrepresented Students in High School Science Courses[(t)]

	PERCENT HUS
Non-college prep	43 (2.8)
1st year biology	35 (3.0)
1st year chemistry	35 (2.2)
1st year physics	30 (3.0)
Advanced science courses	27 (3.9)

(t) Trend item

The study also allows for an estimate of the percentages of different types of science courses in the nation. As can be seen in Table 4.4, the distribution of courses between high-HUS classes and low-HUS classes is significantly different. This difference is likely due to high-HUS classes being over represented at the non-college prep level (40 percent in the highest quartile vs. 23 percent in the lowest quartile) and under-represented at the advanced level (12 percent in the highest quartile vs. 23 percent in the lowest quartile). These data are not significantly different from the 2012 data.

Table 4.4
Prevalence of High School Science Courses, by HUS Quartile[(t)]

	PERCENT OF CLASSES*			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
Non-college prep	23 (2.7)	23 (2.5)	28 (2.8)	40 (5.1)
1st year biology	23 (2.9)	24 (3.1)	21 (3.4)	23 (3.9)
1st year chemistry	14 (1.7)	16 (1.9)	17 (1.9)	14 (2.4)
1st year physics	8 (1.4)	12 (2.1)	7 (1.3)	5 (1.4)
1st year multi-discipline science courses	6 (1.6)	3 (1.0)	7 (1.7)	4 (1.6)
1st year environmental science	2 (1.0)	2 (0.9)	3 (2.3)	1 (0.7)
1st year Earth/space Science	2 (0.8)	2 (0.9)	3 (1.1)	0 --[a]
Advanced science courses	23 (2.6)	17 (2.2)	14 (2.6)	12 (5.0)

(t) Trend item

* There is a statistically significant difference in the distribution between classes in the lowest quartile and those in the highest quartile (Chi-square test of independence, $p < 0.05$).

[a] No teachers in this quartile selected this class type. Thus, it is not possible to calculate the standard error of this estimate.

Teachers' Perceptions of Their Decision-Making Autonomy

The survey asked teachers about the extent to which they had control over a number of curriculum and instruction decisions for their classes. As can be seen in Table 4.5, a number of differences between the highest and lowest HUS quartiles were present in 2018. In terms of pedagogical decisions, teachers of high-HUS classes were less likely than teachers of low-HUS classes to feel that they had strong control over selecting teaching techniques (52 vs. 67 percent), choosing criteria for grading student performance (40 vs. 59 percent), or determining the amount of instructional time to spend on each topic (26 vs. 48 percent). Looking at curricular decisions, only 30 percent of classes in the highest quartile, compared to 53 percent of classes in the lowest quartile, were taught by teachers who perceived strong control in selecting the sequence in which topics are covered. Teachers of classes in the highest quartile were also less likely than their counterparts in the lowest quartile to perceive having strong control over selecting curriculum materials (18 vs. 34 percent).

Table 4.5
Science Classes in Which Teachers Felt Strong Control Over Various Curricular and Instructional Decisions, by HUS Quartile

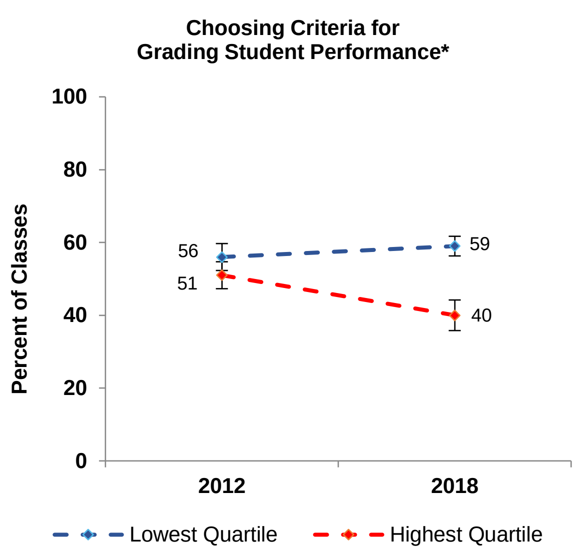
	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Determining the amount of homework to be assigned	71 (2.5)	66 (2.9)	65 (2.6)	63 (4.0)
(t) Selecting teaching techniques*	67 (2.6)	60 (3.3)	51 (3.1)	52 (3.9)
(t) Choosing criteria for grading student performance*	59 (2.7)	50 (3.1)	45 (3.0)	40 (4.2)
Selecting the sequence in which topics are covered*	53 (2.8)	41 (2.7)	29 (3.1)	30 (4.7)
Determining the amount of instructional time to spend on each topic*	48 (2.5)	35 (2.6)	24 (2.8)	26 (4.9)
(t) Determining course goals and objectives	35 (2.6)	25 (2.5)	18 (2.1)	25 (5.2)
(t) Selecting content, topics, and skills to be taught	30 (2.5)	23 (2.6)	14 (1.6)	21 (5.1)
(t) Selecting curriculum materials (e.g., textbooks/online courses)*	34 (2.6)	29 (2.8)	14 (1.8)	18 (4.9)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

Figure 4.1 shows a widening of the gap over time between high-HUS classes and low-HUS classes in teachers' perceptions of control over choosing criteria for grading student performance. The percentage of high-HUS classes taught by teachers who felt strong control in this area decreased from 2012 to 2018 (51 vs. 40 percent), while low-HUS classes taught by teachers who felt strong control stayed mostly consistent between the two years.

Change Over Time: Curricular and Instructional Decisions



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$)

Figure 4.1

The decision-making items were combined into two composite variables—Curriculum Control and Pedagogy Control. The mean scores (see Table 4.6) indicate that teachers of high-HUS classes tended to perceive less control over decisions related to curriculum and pedagogy than their counterparts in low-HUS classes. These data are not significantly different from the data in 2012.

Table 4.6
Science Class Mean Scores for Curriculum Control and Pedagogy Control Composites, by HUS Quartile

	MEAN SCORE			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Curriculum Control*,[a]	63 (1.8)	56 (1.8)	47 (1.7)	49 (4.1)
(t) Pedagogy Control*	87 (1.1)	83 (1.3)	82 (1.1)	79 (2.3)

(t) Trend composite

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed for 2018 using the 2012 definition. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Instructional Objectives

Students' opportunities to learn science are also impacted by the objectives that teachers emphasize in their instruction. In 2018, roughly 60 percent of classes in the highest and lowest HUS quartiles had a heavy emphasis on understanding science concepts, and about one-third of classes had a heavy emphasis on learning how to do science and increasing students' interest in science/engineering (see Table 4.7). However, learning science vocabulary and/or facts received heavy emphasis in significantly more classes in the highest HUS quartile than the lowest (39 vs. 24 percent). Classes in the highest HUS quartile were also more likely to emphasize test-taking skills/strategies than classes in the lowest quartile (30 vs. 19 percent). These same differences between classes were present in 2012.

Table 4.7
Science Classes With Heavy Emphasis on Various Instructional Objectives, by HUS Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Understanding science concepts	62 (1.9)	62 (2.5)	60 (2.3)	59 (2.9)
Learning science vocabulary and/or facts*	24 (1.9)	29 (2.5)	30 (2.2)	39 (2.5)
Learning how to do science (e.g., develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)	38 (2.0)	33 (2.2)	34 (2.1)	33 (3.5)
(t) Increasing students' interest in science/engineering	30 (2.1)	27 (2.2)	31 (2.3)	32 (3.5)
(t) Learning test-taking skills/strategies*	19 (1.7)	16 (1.7)	20 (2.0)	30 (2.2)
Developing students' confidence that they can successfully pursue careers in science/engineering	28 (1.6)	25 (2.2)	28 (2.2)	29 (3.9)
(t) Learning about real-life applications of science/engineering	25 (2.0)	22 (1.8)	24 (1.9)	26 (3.7)
Learning how to do engineering (e.g., identify criteria and constraints, design solutions, optimize solutions)	8 (1.7)	6 (1.1)	6 (0.9)	12 (3.6)
Learning about different fields of science/engineering	6 (1.0)	6 (1.1)	6 (1.3)	12 (3.9)

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

Several of these items were combined into a Reform-Oriented Instructional Objectives composite variable (see Table 4.8). The mean scores indicate that science classes were equally likely to emphasize reform-oriented instructional objectives (e.g., learning how to do science, learning how to do engineering), regardless of HUS quartile. These data are not significantly different from the data in 2012.

Table 4.8
Science Class Mean Scores for the Reform-Oriented Instructional Objectives Composite,[a] by HUS Quartile[(t),†]

	MEAN SCORE
Lowest Quartile Classes	64 (0.8)
Second Quartile Classes	62 (1.0)
Third Quartile Classes	62 (0.8)
Highest Quartile Classes	64 (1.6)

(t) Trend composite

† There is no statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p \geq 0.05$).

a This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed using only the items in common at both time points. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Class Activities

The 2018 NSSME+ included several sets of items that provide information about science instruction. One asked how often different pedagogies were used. As can be seen in Table 4.9, nearly 90 percent of high-HUS and low-HUS classes included leading whole class discussions and explaining science ideas to the whole class at least once a week. Having students work in small groups was also very common regardless of HUS quartile (78–81 percent of all classes). However, there are also some differences. High-HUS classes were more likely than low-HUS classes to focus on literacy skills (60 vs. 42 percent); write their reflections in class or for homework (50 vs. 33 percent); read from a textbook, module, or other materials in class (44 vs. 29 percent) and practice for standardized tests (31 vs. 12 percent). Flipped instruction, although relatively uncommon across classes, was also more likely to be used in high-HUS classes than in low-HUS classes (14 vs. 7 percent). Conversely, high-HUS classes were less likely than low-HUS classes to do hands-on/laboratory activities (52 vs. 61 percent). Taken together, these data suggest that high-HUS classes generally follow a more traditional model of instruction than low-HUS classes.

Table 4.9
Science Classes in Which Teachers Used Various Activities at Least Once a Week, by HUS Quartile

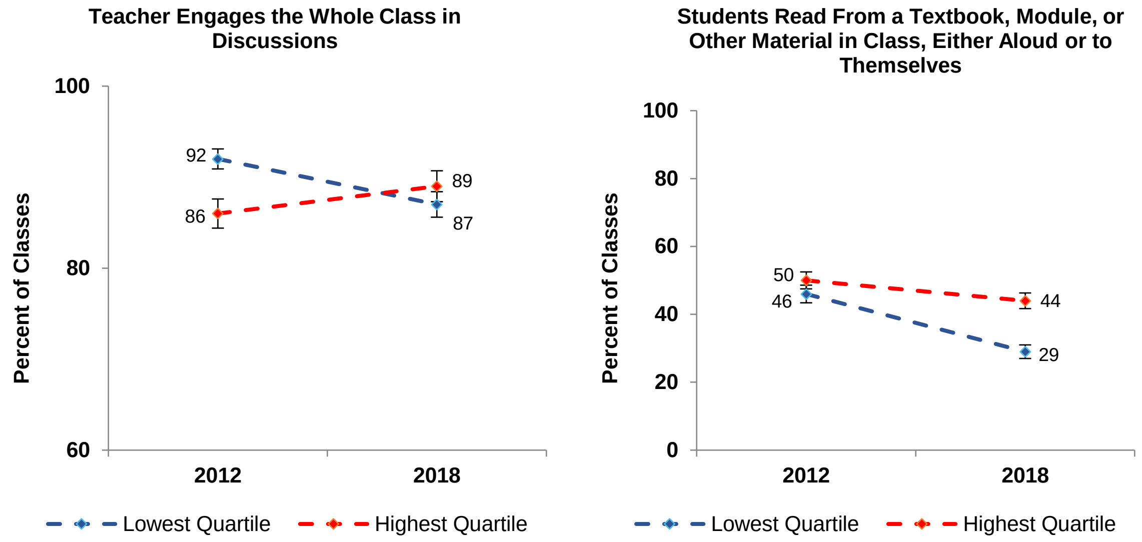
	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Engage the whole class in discussions	87 (1.4)	86 (1.6)	86 (1.3)	89 (1.7)
(t) Explain science ideas to the whole class	89 (1.4)	88 (1.6)	89 (1.4)	88 (3.4)
(t) Have students work in small groups	80 (1.9)	78 (2.3)	79 (2.2)	81 (2.0)
(t) Focus on literacy skills (e.g., informational reading or writing strategies)*	42 (2.0)	44 (2.5)	51 (2.6)	60 (3.4)
(t) Have students do hands-on/laboratory activities*	61 (2.2)	64 (2.7)	59 (2.6)	52 (2.7)
(t) Have students write their reflections (e.g., in their journals, on exit tickets) in class or for homework*	33 (2.3)	35 (2.2)	42 (2.2)	50 (3.0)
(t) Have students read from a textbook, module, or other material in class, either aloud or to themselves*	29 (2.0)	31 (2.1)	33 (2.3)	44 (2.3)
(t) Engage the class in project-based learning (PBL) activities	31 (2.0)	28 (2.5)	24 (1.7)	31 (3.9)
(t) Have students practice for standardized tests*	12 (1.2)	13 (1.4)	18 (1.8)	31 (2.4)
Use flipped instruction (have students watch lectures/demonstrations outside of class to prepare for in-class activities)*	7 (1.0)	10 (1.3)	11 (1.5)	14 (1.7)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

From 2012 to 2018, there was a change in the gap between high-HUS classes and low-HUS classes in which the teacher engaged students in whole class discussions (see Figure 4.2). This difference appears to be due to a slight increase in the use of this activity in high-HUS classes (86 vs. 89 percent) and decrease in the use of this activity in low-HUS classes (92 vs. 87 percent) over time. There was also a widening of the gap between high-HUS classes and low-HUS classes in which students read from textbooks or other materials during class. Although the percentages of both high-HUS and low-HUS classes allocating time for students to read from textbooks and other materials decreased, the decrease was smaller for high-HUS classes (from 50 to 44 percent) and larger for low-HUS classes (from 46 to 29 percent).

Change Over Time:
Weekly Science Class Activities



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$)

Figure 4.2

In 2018, teachers were also asked how often they engage students in the practices of science. Regardless of HUS quartile, relatively low percentages of classes engaged in any of the science practices on a weekly basis (see Table 4.10). However, there are several differences in the percentage of high-HUS classes and low-HUS that engaged in these practices. High-HUS classes were more likely than low-HUS classes to do each of the following on a weekly basis:

- Use multiple sources of evidence to develop an explanation (39 vs. 25 percent);
- Revise their explanations based on additional evidence (31 vs. 20 percent);
- Determine whether or not a question was scientific (31 vs. 22 percent);
- Use data and reasoning to defend a claim or refute alternative scientific claims (27 vs 18 percent);
- Consider how missing data or measurement error can affect the interpretation of data (22 vs. 17 percent);
- Evaluate the strengths and weaknesses of competing scientific explanations (20 vs. 11 percent);
- Determine what details about an investigation might persuade a targeted audience about a scientific claim (18 vs. 10 percent); and
- Construct a persuasive case for the best scientific model or explanation for a real-world phenomenon (16 vs. 10 percent).

However, given that high-HUS classes were more likely than low-HUS classes to engage in a traditional model of education, it is not clear why they were also more likely to engage in many of these practices. This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 4.10
Science Classes in Which Students Engaged in Various Aspects of Science Practices at Least Once a Week, by HUS Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
Make and support claims with evidence	37 (2.3)	40 (2.2)	38 (2.2)	46 (3.4)
Generate scientific questions	38 (2.1)	36 (2.3)	35 (2.0)	46 (3.9)
Organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data	42 (2.0)	42 (2.4)	44 (2.6)	45 (3.1)
Use multiple sources of evidence to develop an explanation*	25 (1.7)	27 (2.4)	30 (1.9)	39 (3.3)
Conduct a scientific investigation	42 (2.2)	43 (2.6)	45 (2.7)	38 (3.4)
Determine what data would need to be collected in order to answer a scientific question	33 (2.3)	32 (2.2)	31 (1.9)	38 (3.9)
Develop procedures for a scientific investigation to answer a scientific question	30 (1.9)	27 (1.8)	31 (2.3)	36 (3.8)
Analyze data using grade-appropriate methods in order to identify patterns, trends, or relationships	36 (2.0)	33 (2.2)	37 (2.5)	35 (3.2)
Revise their explanations based on additional evidence*	20 (1.7)	24 (2.2)	23 (1.9)	31 (3.4)
Determine whether or not a question is scientific*	22 (1.7)	20 (1.5)	22 (1.8)	31 (2.8)
Compare data from multiple trials or across student groups for consistency in order to identify potential sources of error or inconsistencies in the data	27 (1.9)	21 (1.7)	26 (2.3)	29 (3.5)
Develop scientific models—physical, graphical, or mathematical representations of real-world phenomena	24 (1.7)	27 (2.0)	23 (1.7)	29 (3.0)
Summarize patterns, similarities, and differences in scientific information obtained from multiple sources	20 (1.7)	20 (1.8)	19 (1.7)	28 (4.3)
Use data and reasoning to defend, verbally or in writing, a claim or refute alternative scientific claims*	18 (1.5)	21 (2.0)	20 (1.6)	27 (2.5)
Select and use grade-appropriate mathematical and/or statistical techniques to analyze data	19 (1.5)	20 (1.8)	19 (1.8)	23 (2.3)
Identify the strengths and limitations of a scientific model—in terms of accuracy, clarity, generalizability, accessibility to others, strength of evidence supporting it	16 (1.6)	13 (1.1)	13 (1.5)	23 (3.3)
Consider how missing data or measurement error can affect the interpretation of data*	17 (1.4)	16 (1.5)	19 (2.1)	22 (2.5)
Pose questions that elicit relevant details about the important aspects of a scientific argument	18 (1.6)	14 (1.4)	16 (1.6)	22 (2.0)
Evaluate the strengths and weaknesses of competing scientific explanations*	11 (1.3)	13 (1.6)	15 (1.7)	20 (2.4)
Use mathematical and/or computational models to generate data to support a scientific claim	16 (1.5)	15 (1.3)	16 (1.6)	19 (2.1)
Determine what details about an investigation might persuade a targeted audience about a scientific claim*	10 (1.2)	12 (1.3)	12 (1.4)	18 (2.0)
Evaluate the credibility of scientific information—e.g., its reliability, validity, consistency, logical coherence, lack of bias, or methodological strengths and weaknesses	14 (1.5)	12 (1.2)	15 (1.7)	16 (2.1)
Construct a persuasive case, verbally or in writing, for the best scientific model or explanation for a real-world phenomenon*	10 (1.3)	10 (1.2)	13 (1.4)	16 (1.8)

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

Table 4.11 shows the mean scores for Engaging Students in the Practices of Science Composite formed from these items. The composite mean scores indicate that students were only moderately likely to engage in the practices of science. However, students in high-HUS classes were more likely than students in low-HUS classes to engage in these practices (mean scores of 47 vs. 43).

Table 4.11
Science Class Mean Scores for Engaging Students in Practices of Science Composite, by HUS Quartile

	MEAN SCORE*
Lowest Quartile Classes	43 (0.9)
Second Quartile Classes	42 (0.9)
Third Quartile Classes	43 (1.0)
Highest Quartile Classes	47 (1.3)

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

The survey also asked how often students in the randomly selected class were required to take assessments the teacher did not develop (e.g., state or district benchmark assessments). As can be seen in Table 4.12, students in high-HUS classes were more likely be tested two or more times per year than those in low-HUS classes (38 vs. 21 percent).

Table 4.12
Science Classes Required to Take External Assessments Two or More Times Per Year, by HUS Quartile(t)

	PERCENT OF CLASSES*
Lowest Quartile Classes	21 (2.1)
Second Quartile Classes	28 (2.6)
Third Quartile Classes	36 (3.1)
Highest Quartile Classes	38 (4.0)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

Summary

A number of aspects of science instruction were relatively similar between classes in the highest and lowest HUS quartiles in 2018, but there are also some notable differences in the data. At the elementary level, high-HUS classes spent more time on science instruction than low-HUS classes. Of course, whether that finding is positive or negative depends on how that additional time was being spent. Further, regardless of HUS quartile, time spent on science instruction at the elementary level was substantially less than time spent on reading/language arts or mathematics. In terms of course enrollment at the secondary level, students from race/ethnicity groups historically underrepresented in STEM made up a substantial proportion of students in non-college prep science classes, but smaller percentages of the students in more advanced courses.

Data about teachers' perceptions of control and emphasis on instructional objectives were also mixed. Science classes, regardless of HUS quartile, had similar emphasis on reform-oriented instructional objectives (e.g., understanding science concepts, learning how to do science). Teachers across all classes also felt that they had greater control over decisions related to pedagogy than curriculum. However, teachers of high-HUS classes felt less control over decisions related to curriculum and pedagogy than teachers of low-HUS classes.

The types of instructional activities used in classrooms varied based on HUS quartile. Whole group discussion, small group work, and the teacher explaining ideas were prominent weekly activities in both high-HUS and low-HUS classes. However, high-HUS classes were less likely than low-HUS classes to do hands on/laboratory activities and more likely to focus on literacy skills, write reflections, read from a textbook, and practice for standardized tests. Classes in the highest HUS quartile were also more likely than classes in the lowest quartile to be required to take two or more external science assessments in a school year.

Similarly, there was variation in students' opportunities to engage in a number of science practices. Regardless of HUS quartile, the majority of classes included weekly opportunities for students to make and support claims with evidence, generate scientific questions, and organize/represent data. However, high-HUS classes were more likely than low-HUS classes to include opportunities for students to engage in several practices, including using multiple sources of evidence to develop an explanation and determining whether or not a question was scientific. However, given that high-HUS classes were more likely than low-HUS classes to engage in a traditional model of education, it is not clear why they were also more likely to engage in many of these practices.

From 2012 to 2018, the nature of science instruction provided in high-HUS and low-HUS classes remained largely consistent. One notable difference is in teachers' perceptions of control over choosing criteria for grading student performance, an area in which the gap widened in favor of teachers in low-HUS classes. There are also two differences in the prevalence of class activities. The gap between high-HUS and low-HUS classes in which the teacher engages the whole class in discussions on a weekly basis decreased over time. Conversely, there was a widening of the gap between classes in which students read from a textbook or other material, with high-HUS classes more likely than low-HUS classes to include opportunities to do so at least once a week.

Material Resources

As described in previous chapters, the 2018 NSSME+ included a number of items about the resources available for science instruction. This section of the report provides information about material resources, disaggregated by HUS quartile.

Instructional Materials

In 2018, a majority of science classes had materials designated by their district for science instruction, although it was more likely in high-HUS classes than low-HUS classes (see Table 4.13). Commercially published textbooks were by far the most commonly designated science materials across quartiles. Other types of materials were more likely to be designated for use in high-HUS classes than low-HUS classes, including:

- State-, county-, or district-developed units or lessons (44 vs. 27 percent);
- Lessons or resources from websites that have a subscription fee or per lesson cost (38 vs. 26 percent);
- Lessons or resources from websites that are free (29 vs. 16 percent); and
- Online units or courses that students work through at their own pace (16 vs. 8 percent).

These data suggest that teachers in high-HUS classes may have less control over their curriculum than teachers in low-HUS classes. This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 4.13
Types of Instructional Materials Designated for Science Classes, by HUS Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
District Designates Instructional Materials*				
No	40 (2.5)	37 (2.8)	33 (3.0)	23 (3.6)
Yes	60 (2.5)	63 (2.8)	67 (3.0)	77 (3.6)
Types of Designated Instructional Materials[a]				
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	80 (3.4)	78 (3.3)	73 (3.6)	81 (3.1)
State, county, district, or diocese-developed units or lessons*	27 (3.0)	35 (3.6)	39 (3.0)	44 (3.3)
Commercially published kits/modules (printed or electronic)	41 (3.8)	41 (3.2)	37 (3.4)	43 (3.1)
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)*	26 (2.8)	33 (3.2)	34 (2.9)	38 (4.1)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)*	16 (2.3)	23 (2.0)	21 (2.2)	29 (3.1)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)*	8 (1.8)	9 (1.8)	7 (1.3)	16 (2.1)

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] Only science classes for which instructional materials are designated by the state, district, or diocese are included in these analyses.

Regardless of whether instructional materials had been designated for their class, teachers were asked how often instruction was based on various types of materials. Interestingly, units or lessons created by the teacher were the most commonly used materials, serving as the basis of instruction at least once a week in over half of all science classes (see Table 4.14). Although less prevalent overall, high-HUS classes were more likely than low-HUS classes to base instruction on lessons or resources from websites that are free (41 vs 30 percent); state-, county-, or district-developed materials (33 vs. 17 percent), and online units or courses that students work through at their own pace (10 vs. 6 percent). This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 4.14
Science Classes Basing Instruction on Various Types of Instructional Materials at Least Once a Week, by HUS Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
Units or lessons you created (either by yourself or with others)	67 (2.6)	67 (2.6)	62 (2.9)	58 (3.7)
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	46 (2.2)	41 (2.6)	36 (2.6)	48 (3.3)
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)*	30 (2.4)	35 (2.3)	41 (2.9)	41 (3.4)
Units or lessons you collected from any other source (e.g., conferences, journals, colleagues, university or museum partners)	37 (2.3)	37 (2.5)	35 (2.4)	39 (3.2)
State, county, district, or diocese-developed units or lessons*	17 (1.5)	21 (2.1)	27 (2.2)	33 (4.2)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	24 (1.5)	24 (1.8)	29 (2.4)	31 (3.5)
Commercially published kits/modules (printed or electronic)	26 (2.1)	23 (2.3)	23 (1.9)	26 (2.6)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)*	6 (0.9)	7 (1.1)	8 (1.3)	10 (1.4)

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

Teachers who used commercially published textbooks were asked to record information about the textbook used most often in the class, including publication year. As can be seen in Table 4.15, more than 70 percent of classes, regardless of HUS quartile, used textbooks that were six or more years old. The 2018 data are not significantly different from the 2012 data.

Table 4.15
Age of Science Textbooks in 2018, by HUS Quartile(t),†

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
6 or more years	74 (3.1)	72 (4.2)	70 (3.3)	73 (4.1)
5 or fewer years	26 (3.1)	28 (4.2)	30 (3.3)	27 (4.1)

(t) Trend item

† There is no statistically significant difference in the distribution between classes in the lowest quartile and those in the highest quartile (Chi-square test of independence, $p \geq 0.05$).

Facilities and Equipment

Teachers were asked to rate the adequacy of a number of instructional resources available for instruction. As can be seen in Table 4.16, large percentages of classes had access to projection devices and balances; however, these resources were less likely to be available in high-HUS classes than low-HUS classes. Additionally, probes for collecting data were less likely to be available in classes in high-HUS classes than low-HUS classes (47 vs. 64 percent). The differences in the availability of these technologies according to HUS quartile have not changed significantly since 2012.

Table 4.16
Availability[a] of Instructional Resources in Science Classes, by HUS Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
Projection devices (e.g., Smartboard, document camera, LCD projector)*	99 (0.6)	98 (0.7)	99 (0.4)	96 (1.4)
Balances (e.g., pan, triple beam, digital scale)*	92 (1.4)	91 (1.6)	89 (1.9)	80 (2.8)
(t) Microscopes	78 (2.7)	75 (2.5)	71 (3.2)	70 (3.4)
(t) Probes for collecting data (e.g., motion sensors, temperature probes)*	64 (3.2)	60 (3.6)	56 (3.3)	47 (4.4)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

a Includes only those teachers indicating the resource is always available in their classroom or available upon request.

Teachers were also asked about the availability of laboratory facilities for science instruction (see Table 4.17). Electric outlets and faucets and sinks were both widely available for science classes but were less so in high-HUS classes than low-HUS classes (92 vs. 97 percent and 81 vs. 90 percent, respectively). More than half of all classes also had access to lab tables, but again fewer high-HUS classes had access than low-HUS classes (52 vs. 63 percent). At the high school level, gas for burners and fume hoods were quite common, although fume hoods were available in fewer high-HUS classes than low-HUS classes (71 vs. 86 percent). The 2018 data are not significantly different from the 2012 data.

Table 4.17
Availability[a] of Laboratory Facilities in Science Classes, by HUS Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Electric outlets*	97 (0.9)	96 (1.1)	96 (1.4)	92 (1.6)
(t) Faucets and sinks*	90 (2.0)	89 (2.5)	89 (2.0)	81 (2.4)
(t) Gas for burners[b]	88 (2.7)	88 (2.8)	87 (2.9)	77 (6.1)
(t) Fume hoods*[,b]	86 (2.5)	82 (3.6)	84 (3.0)	71 (5.7)
(t) Lab tables*	63 (2.2)	56 (3.2)	57 (3.8)	52 (3.6)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

a Includes only those science teachers indicating the resource is either located in the classroom or available in another room.

b This item was presented only to high school teachers..

Additionally, teachers were asked about the adequacy of their available instructional resources. As can be seen in Table 4.18, teachers of classes in the highest HUS quartile were less likely than their counterparts in the lowest HUS quartile to rate instructional technology, facilities, and consumable supplies as adequate. The same inequities between classes were present in 2012.

Table 4.18
Adequacy[a] of Resources for Science Instruction, by HUS Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Instructional technology (e.g., calculators, computers, probes/sensors)*	63 (2.8)	59 (3.3)	53 (2.7)	51 (4.6)
(t) Equipment (e.g., thermometers, magnifying glasses, microscopes, beakers, photogate timers, Bunsen burners)	58 (3.1)	55 (3.2)	48 (2.5)	47 (4.4)
(t) Facilities (e.g., lab tables, electric outlets, faucets and sinks)*	59 (2.4)	54 (3.1)	51 (2.9)	45 (3.9)
(t) Consumable supplies (e.g., chemicals, living organisms, batteries)*	50 (2.9)	50 (3.3)	40 (2.4)	33 (4.4)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

a Includes science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not adequate" to 5 "adequate."

These items were combined into a composite variable called Adequacy of Resources for Science Instruction. As shown in Table 4.19, teachers of high-HUS classes had less-positive views about their resources compared to those in low-HUS classes (mean scores of 56 vs. 65). The 2018 data are not significantly different from the 2012 data.

Table 4.19
Science Class Mean Scores for the Adequacy of Resources for Instruction Composite, by HUS Quartile[(t)]

	MEAN SCORE*
Lowest Quartile Classes	65 (1.7)
Second Quartile Classes	64 (1.7)
Third Quartile Classes	60 (1.4)
Highest Quartile Classes	56 (2.9)

(t) Trend composite

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

Summary

The distribution and use of material resources for science instruction between classes in the highest and lowest HUS quartiles are similar in some ways, but there are also many differences. The majority of classes had district-designated materials for science instruction, most commonly commercially published textbooks. High-HUS classes were more likely than low-HUS classes to have other types of materials designated for use, such as state-, county-, or district-developed lessons or lessons from paid websites. However, regardless of whether instructional materials had been designated for their class, teachers in high-HUS and low-HUS classes most frequently used units or lessons they created as the basis of their science instruction.

Instructional resources (e.g., projection devices and probes for collecting data) and laboratory facilities (e.g., faucets and sinks, lab tables) were generally less likely to be available in high-HUS classes than low HUS-classes. Disparities were also seen in teachers' perceptions of the adequacy of resources for science instruction, in favor of low HUS-classes. Further, teachers of classes in the highest HUS quartile had less positive views about the resources available to them than those in classes in the lowest HUS quartile.

Because survey items related to material resources were either added, removed, or substantially modified between 2012 and 2018, trend analysis was limited. When trend analyses were conducted, there were no significant changes since 2012.

Well-Prepared Teachers

Teachers are clearly one of the most important factors affecting students' education experience. The 2018 NSSME+ collected data on a number of indicators of teacher preparedness, including their years of teaching experience, content preparation, beliefs about teaching and learning, perceptions of preparedness to teach science content and use classroom pedagogies, and professional development experiences. The extent to which well-prepared teachers were equally distributed among classes with different percentages of students from race/ethnicity groups historically underrepresented in STEM is described in the following sections.

Teacher Characteristics and Preparation

Table 4.20 provides information about the characteristics and preparation of science teachers. About three-quarters of classes across the elementary and middle grades levels, regardless of HUS quartile, were taught by teachers who had completed the majority of NSTA recommended courses. Similarly, about three-quarters of all classes at the secondary level were taught by teachers with a degree in science or science education. However, there are also some differences. For example, classes in the highest quartile were vastly more likely than classes in the lowest quartile to be taught by teachers from historically underrepresented race/ethnicity groups (42 vs. 2 percent). However, classes in the highest quartile were also more likely to be taught by teachers with 0–5 years of science teaching experience (40 vs. 27 percent). At the secondary level, classes in the highest quartile were less likely to be taught by teachers with a degree or 3+ advanced courses in the subject than classes in the lowest quartile (56 vs. 63 percent). The 2018 teacher preparation data are not significantly different from the 2012 data.

Table 4.20
Teacher Characteristics, by HUS Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Teacher completed all or all but one of the NSTA-recommended courses[a]	72 (3.1)	74 (2.9)	71 (2.9)	77 (2.8)
(t) Secondary teacher with a degree in science or science education	78 (2.9)	83 (2.2)	74 (2.7)	73 (3.9)
(t) Secondary teacher with a degree or 3+ advanced courses in the subject	63 (3.0)	67 (3.1)	57 (2.9)	56 (5.0)
(t) Historically underrepresented race/ethnicity group*	2 (0.7)	6 (1.1)	13 (1.4)	42 (4.1)
(t) 0–5 years of experience teaching science*	27 (2.0)	29 (2.1)	38 (2.7)	40 (3.7)
Full-time job experience in science or engineering prior to teaching	18 (2.1)	15 (1.9)	14 (1.7)	19 (2.5)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] NSTA only has recommended courses for elementary and middle school grades teachers; high school teachers are not included.

Teacher Pedagogical Beliefs

Because beliefs are important mediators of behaviors, teachers were asked about their beliefs related to effective teaching and learning. As can be seen in Table 4.21, teachers held a number of reform-oriented beliefs, regardless of HUS quartile. For example, more than 90 percent of high-

HUS and low-HUS classes were taught by teachers who agreed that: (1) they should ask students to support their conclusions about a science concept with evidence; (2) students learn best when instruction is connected to their everyday lives; (3) students should learn science by doing science, (4) most class periods should provide opportunities for students to share their thinking and reasoning, and (5) most class periods should provide opportunities for students to apply scientific ideas to real-world contexts.

Although traditional beliefs were somewhat less commonly held in general, high-HUS classes were more likely than low-HUS classes to be taught by teachers who agreed that teachers should explain an idea to students before having them consider evidence that relates to the idea (42 vs. 29 percent). The 2018 data are not significantly different from the 2012 data.

Table 4.21
Science Classes in Which Teachers Agreed[a] With Various Statements About Teaching and Learning, by HUS Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
Reform-Oriented Beliefs				
Teachers should ask students to support their conclusions about a science concept with evidence.	97 (1.0)	97 (1.7)	96 (1.1)	96 (1.3)
Students learn best when instruction is connected to their everyday lives.	97 (0.8)	97 (0.9)	95 (1.0)	96 (1.2)
Students should learn science by doing science (e.g., developing scientific questions; designing and conducting investigations; analyzing data; developing models, explanations, and scientific arguments).	94 (1.2)	94 (1.6)	94 (1.3)	96 (1.3)
(t) Most class periods should provide opportunities for students to share their thinking and reasoning.	92 (1.4)	94 (1.6)	95 (1.1)	95 (1.2)
Most class periods should provide opportunities for students to apply scientific ideas to real-world contexts.	93 (1.5)	92 (1.9)	92 (1.5)	93 (1.6)
(t) It is better for science instruction to focus on ideas in depth, even if that means covering fewer topics.	76 (2.2)	76 (2.5)	77 (2.6)	72 (3.0)
Traditional Beliefs				
(t) At the beginning of instruction on a science idea, students should be provided with definitions for new scientific vocabulary that will be used.	67 (2.9)	67 (3.0)	73 (2.5)	78 (4.8)
(t) Hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned.	53 (2.4)	49 (3.0)	50 (2.4)	63 (4.3)
(t) Teachers should explain an idea to students before having them consider evidence that relates to the idea.*	29 (2.7)	31 (2.6)	30 (2.3)	42 (3.3)
(t) Students learn science best in classes with students of similar abilities.	41 (2.9)	41 (2.7)	37 (2.6)	40 (3.2)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes teachers indicating "strongly agree" or "agree" on a five-point scale ranging from 1 "strongly disagree" to 5 "strongly agree."

These items were combined into two composite variables: Reform-Oriented Teaching Beliefs and Traditional Teaching Beliefs. The mean scores suggest that reform-oriented beliefs were more commonly held than traditional beliefs (see Table 4.22). However, there are no differences in beliefs between the highest and lowest HUS quartiles. The 2018 data for Traditional Teaching Beliefs composite are not significantly different from the 2012 data.[28]

Table 4.22
Science Class Mean Scores for Teachers' Beliefs About Teaching and Learning Composites, by HUS Quartile†

	MEAN SCORE			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
Reform-Oriented Teaching Beliefs	86 (0.7)	86 (0.8)	87 (0.6)	87 (0.9)
(t) Traditional Teaching Beliefs[a]	56 (1.1)	55 (1.2)	55 (1.0)	59 (2.5)

(t) Trend composite

† There are no statistically significant differences between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p \geq 0.05$).

[a] This composite variable was not originally computed for the 2012 study. To allow for comparisons across time, it was computed for 2012 using the 2018 definition.

Teachers' Perceptions of Preparedness

The survey asked teachers how well prepared they felt to teach each of a number of science topics at their assigned grade level. At the elementary level, teachers of classes in the highest and lowest HUS quartiles felt equally well prepared to teach life science, Earth/space science, physical science, and engineering (see Table 4.23). However, it is worth noting that fewer than 30 percent felt very well prepared in any of these areas. The 2018 data are not significantly different from the 2012 data.

Table 4.23
Elementary Classes in Which Teachers Considered Themselves Very Well Prepared to Teach Various Science Topics, by HUS Quartile†

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Life Science	25 (3.6)	25 (3.5)	29 (4.0)	24 (3.4)
(t) Physical Science	14 (2.5)	11 (2.7)	14 (3.1)	23 (5.6)
(t) Earth/space Science	16 (2.9)	20 (3.3)	23 (3.8)	22 (3.5)
(t) Engineering	4 (1.6)	5 (2.7)	2 (1.3)	7 (6.1)

(t) Trend item

† There are no statistically significant differences between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p \geq 0.05$).

At the secondary level, teachers of classes in the highest and lowest HUS quartiles felt equally well prepared to teach most science topics (see Table 4.24). However, looking at Earth/space science, teachers of high-HUS classes were less likely than teachers of low-HUS classes to feel very well prepared to teach about climate and weather (27 vs. 43 percent). Within chemistry, teachers of high-HUS classes were less likely than teachers of low-HUS classes to feel very well prepared to teach about elements, compounds, and mixtures (55 vs. 69 percent); chemical

[28] Too few of the items in the 2018 Reform-Oriented Beliefs composite were also asked in 2012 to allow for a comparable composite to be created to examine trends over time.

bonding, equations, nomenclature, and reactions (41 vs. 55 percent); and properties of solutions (37 vs. 53 percent). Additionally, physics teachers of high-HUS classes were less likely than teachers of low-HUS classes to feel very well prepared to teach about properties and behaviors of waves.

Table 4.24
Secondary Science Classes in Which Teachers[a] Considered Themselves Very Well Prepared to Teach Each of a Number of Topics, by HUS Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
Earth/Space Science				
(t) Earth's features and physical processes	49 (5.3)	58 (4.8)	47 (4.8)	39 (5.5)
(t) The solar system and the universe	44 (5.3)	41 (4.6)	39 (4.6)	36 (5.1)
(t) Climate and weather*	43 (4.7)	39 (4.7)	37 (4.4)	27 (4.1)
Biology/Life Science				
(t) Structures and functions of organisms	64 (3.8)	63 (4.7)	68 (3.1)	63 (4.6)
(t) Cell biology	63 (3.9)	60 (4.4)	65 (3.8)	62 (4.6)
(t) Ecology/ecosystems	60 (3.5)	64 (4.6)	61 (4.0)	55 (4.9)
(t) Genetics	59 (3.8)	61 (4.4)	60 (4.5)	50 (4.4)
(t) Evolution	51 (3.7)	54 (4.2)	57 (4.2)	42 (4.4)
Chemistry				
(t) States, classes, and properties of matter	72 (3.9)	75 (3.7)	66 (3.8)	58 (5.2)
(t) Atomic structure	66 (3.7)	72 (3.8)	58 (3.2)	56 (5.2)
(t) Elements, compounds, and mixtures*	69 (4.2)	70 (4.0)	58 (3.7)	55 (5.4)
(t) The periodic table	67 (4.5)	71 (4.5)	57 (3.7)	57 (5.0)
(t) Chemical bonding, equations, nomenclature, and reactions*	55 (4.4)	56 (4.5)	45 (3.6)	41 (4.5)
(t) Properties of solutions*	53 (4.1)	54 (4.5)	45 (3.3)	37 (4.0)
Physics				
(t) Energy transfers, transformations, and conservation	50 (4.6)	55 (3.8)	51 (4.1)	45 (4.6)
(t) Forces and motion	54 (4.9)	61 (3.9)	46 (4.3)	47 (4.5)
(t) Electricity and magnetism	26 (4.1)	30 (3.5)	26 (3.9)	26 (4.0)
(t) Properties and behaviors of waves*	37 (4.2)	34 (3.4)	30 (3.8)	24 (3.7)
(t) Modern physics	12 (2.7)	15 (3.0)	7 (1.6)	11 (1.3)
(t) **Environmental and Resource Issues** (e.g., land and water use, energy resources and consumption, sources and impacts of pollution)	49 (5.4)	37 (4.8)	40 (5.0)	35 (2.7)

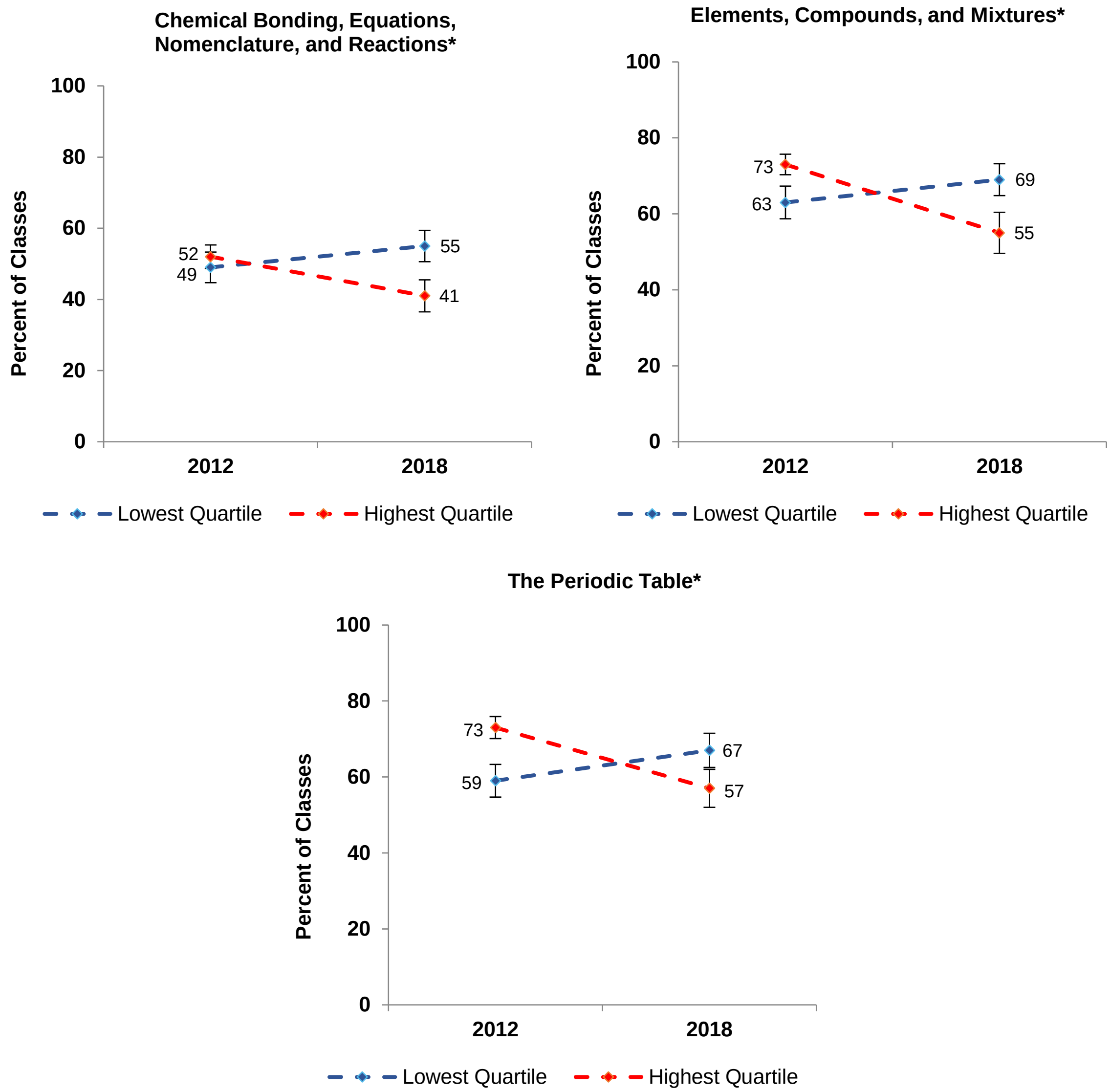
(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] Each secondary science teacher was asked about one set of science topics based on the discipline of his/her randomly selected class.

Looking at teachers' feelings of preparedness to teach science topics over time, there are several notable differences by HUS quartile. From 2012 to 2018, there were changes between the highest and lowest quartiles in teachers' preparedness to teach a number of chemistry topics, including: (1) chemical bonding, equations, nomenclature, and reactions; (2) elements, compounds, and mixtures; and (3) the periodic table (see Figure 4.3). In each case, the change in the gap favors students in low-HUS classes.

Change Over Time:
Preparedness to Teach Secondary Science: Chemistry



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$)

Figure 4.3

As can be seen in Table 4.25, few science classes at the secondary level were taught by teachers who considered themselves very well prepared to teach engineering topics. However, teachers of high-HUS classes were even less likely than their counterparts in low-HUS classes to feel well prepared to teach about defining engineering problems and optimizing design solutions (5 vs. 11 percent and 4 vs. 9 percent, respectively). This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 4.25
Secondary Science Classes in Which Teachers Considered Themselves Very Well Prepared to Teach Each of a Number of Engineering Topics, by HUS Quartile

	PERCENT OF TEACHERS			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
Developing possible solutions	12 (1.6)	11 (1.3)	11 (1.7)	8 (2.1)
Defining engineering problems*	11 (1.7)	8 (1.2)	9 (1.6)	5 (1.0)
Optimizing design solutions*	9 (1.4)	8 (1.3)	8 (1.7)	4 (0.9)

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

The survey also asked teachers how well prepared they felt to use a number of student-centered pedagogies. As can be seen in Table 4.26, high-HUS classes and low-HUS classes were equally likely to be taught by teachers who felt very well prepared to use formative assessment to monitor student learning, encourage students' interest in science and/or engineering, differentiate science instruction, provide science instruction based on student's ideas, and develop students' awareness of STEM careers. However, differences by HUS quartile are also evident. Teachers of high-HUS classes considered themselves less well prepared than their counterparts in low-HUS classes to encourage participation of all students in science and/or engineering (31 vs. 40 percent), develop students' conceptual understanding (30 vs. 40 percent), or develop students' abilities to do science (22 vs. 35 percent). Conversely, teachers of high-HUS classes felt better prepared than teachers of low-HUS classes to incorporate students' cultural backgrounds into science instruction (18 vs. 10 percent). For the one trend item, there is no significant difference over time.

Table 4.26
Science Classes in Which Teachers Considered Themselves Very Well Prepared for Each of a Number of Tasks, by HUS Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
Use formative assessment to monitor student learning	41 (1.9)	42 (2.3)	44 (2.1)	36 (3.8)
Encourage participation of all students in science and/or engineering*	40 (1.9)	42 (2.6)	38 (2.1)	31 (3.5)
(t) Encourage students' interest in science and/or engineering	37 (1.8)	39 (2.4)	37 (1.9)	31 (3.3)
Develop students' conceptual understanding*	40 (1.9)	40 (2.6)	40 (2.7)	30 (2.8)
Differentiate science instruction to meet the needs of diverse learners	25 (1.9)	27 (2.1)	30 (1.9)	27 (3.8)
Develop students' abilities to do science (e.g., develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)*	35 (2.4)	34 (2.2)	30 (1.9)	22 (2.3)
Provide science instruction that is based on students' ideas	17 (1.5)	18 (1.8)	18 (2.1)	21 (3.7)
Develop students' awareness of STEM careers	14 (1.4)	15 (1.3)	14 (1.5)	19 (3.2)
Incorporate students' cultural backgrounds into science instruction*	10 (1.1)	11 (1.3)	18 (1.5)	18 (1.9)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

Table 4.27 shows the percentage of science classes taught by teachers who felt very well prepared for each of a number of tasks related to monitoring and addressing student thinking within a particular unit in a designated class. A number of differences by HUS quartile are apparent. Teachers of classes in the highest HUS quartile perceived themselves as less well prepared than teachers in the lowest HUS quartile classes to assess student understanding at the conclusion of the unit (38 vs. 49 percent), monitor student understanding during the unit (36 vs. 46 percent), implement the instructional materials to be used during the unit (34 vs. 43 percent), and anticipate difficulties that students may have with particular science ideas and procedures in the unit (24 vs. 35 percent). When looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 4.27
Science Classes in Which Teachers Felt Very Well Prepared for Various Tasks in the Most Recent Unit, by HUS Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Assess student understanding at the conclusion of this unit*	49 (2.3)	49 (2.4)	44 (2.6)	38 (2.9)
(t) Monitor student understanding during this unit*	46 (1.9)	44 (2.5)	43 (2.6)	36 (2.9)
(t) Implement the instructional materials to be used during this unit*	43 (2.2)	48 (2.3)	37 (2.7)	34 (2.9)
(t) Find out what students thought or already knew about the key science ideas	35 (1.9)	38 (2.3)	34 (2.4)	32 (4.4)
(t) Anticipate difficulties that students may have with particular science ideas and procedures in this unit*	35 (2.0)	35 (2.2)	32 (2.7)	24 (2.6)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

The preparedness items were used to create four composite variables: Perceptions of Content Preparedness, Perceptions of Preparedness to Teach Engineering, Perceptions of Pedagogical Preparedness, and Perceptions of Preparedness to Implement Instruction in a Particular Unit. As can be seen in Table 4.28, there are no differences between high-HUS and low-HUS classes in terms of teachers' preparedness to teach engineering or their pedagogical preparedness. However, high-HUS classes were less likely than low-HUS classes to be taught by teachers who had strong feelings of science content preparedness (mean scores of 62 vs. 67) and preparedness to implement instruction in a particular unit (mean scores of 70 vs. 75). The 2018 data for the Science Content Preparedness and Preparedness to Implement Instruction in a Particular Unit composites are not significantly different from the 2012 data.[29]

[29] Too few of the items in the 2018 version of the Pedagogical Preparedness composite were also asked in 2012 to allow for a comparable composite to be created to examine trends over time. The Engineering Content Preparedness composite is new to the 2018 NSSME+; thus, trend data are not available to report.

Table 4.28
Science Class Mean Scores for Teachers' Perceptions of Preparedness Composites, by HUS Quartile

	MEAN SCORE			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Perceptions of Content Preparedness*,[a]	67 (1.4)	66 (1.3)	63 (1.5)	62 (1.5)
Perceptions of Preparedness to Teach Engineering	38 (1.8)	36 (1.6)	39 (1.6)	36 (2.2)
Perceptions of Pedagogical Preparedness	64 (0.9)	65 (1.0)	64 (1.1)	62 (1.7)
(t) Perceptions of Preparedness to Implement Instruction in Particular Unit*	75 (1.0)	77 (0.9)	74 (1.0)	70 (1.4)

(t) Trend composite

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed for 2018 using the 2012 definition. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Teacher Professional Development

It is important that science teachers have opportunities to continue to develop their disciplinary content knowledge and pedagogical skills. Accordingly, the 2018 NSSME+ collected data on teachers' participation in professional development.

Regardless of HUS quartile, nearly three-quarters of classes were taught by teachers who participated in science-focused professional development in the previous three years (see Table 4.29). However, classes in the highest quartile were less likely than classes in the lowest quartile to be taught by a teacher with more than 35 hours of science-focused professional development within that timeframe (15 vs. 20 percent).

Table 4.29
Professional Development Experiences of Teachers of Science Classes, by HUS Quartile

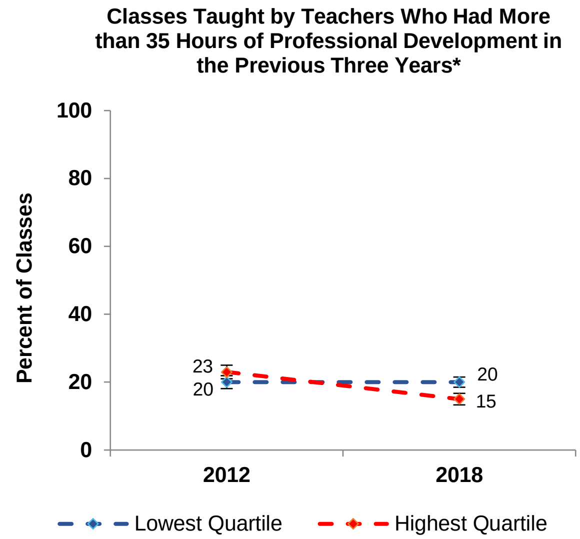
	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Teacher has had PD in the previous three years	68 (1.9)	70 (2.4)	73 (2.7)	74 (2.6)
(t) Teacher has had more than 35 hours of PD in the previous three years*	20 (1.5)	18 (1.7)	19 (1.6)	15 (1.7)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

Looking at trends over time, there was a slight change in the gap between high-HUS classes and low-HUS classes taught by teachers with more than 35 hours of professional development (see Figure 4.4). In 2012, 23 percent of high-HUS classes were taught by teachers with more than 35 hours of professional development compared to 20 percent of low-HUS classes. In 2018, only 15 percent of high-HUS classes, compared to 20 percent of low-HUS classes, were taught by teachers with more than 35 hours of professional development.

Change Over Time:
Amount of Professional Development



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$)

Figure 4.4

The effectiveness of professional development depends on the extent to which the experience is structured and facilitated to provide teachers with meaningful learning opportunities. As described in previous chapters, there is consensus that teachers should have opportunities to work with colleagues, engage in investigations, examine student work, and apply what they have learned in their classrooms and subsequently discuss how it went.[30] Thus, teachers who had participated in professional development in the previous three years were asked a series of additional questions about the nature of those experiences.

As can be seen in Table 4.30, teachers of classes in the highest and lowest HUS quartiles who had attended professional development had similar experiences. For example, over half of classes were taught by teachers who worked closely with other teachers from their schools, and nearly as many worked with other teachers who taught the same grade and/or subject whether or not they were from their schools. Roughly 35–50 percent of classes in both quartiles were also taught by teachers who participated in professional development that included experiencing lessons as their students would from the textbooks/units they use and engaging in science investigations/engineering design challenges.

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[30] Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, *38*(3), 181–199.

Elmore, R. F. (2002). *Bridging the gap between standards and achievement: The imperative for professional development in education.* Albert Shanker Institute.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal*, *38*(4), 915–945.

Table 4.30
Science Classes in Which Teachers' Professional Development in the Previous Three Years Had Each of a Number of Characteristics to a Substantial Extent,[a] by HUS Quartile[†]

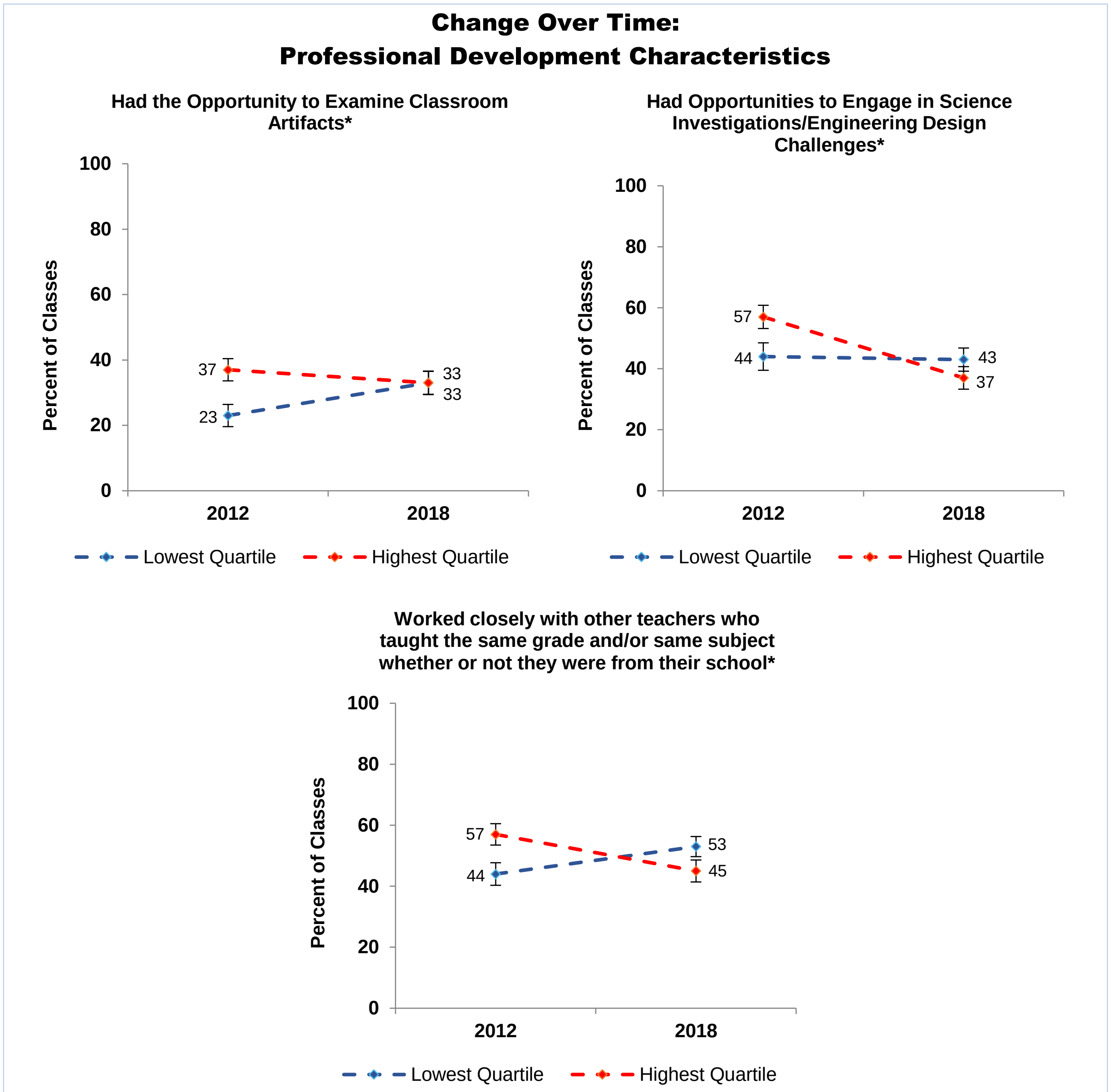
	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Worked closely with other teachers from their school	53 (3.3)	55 (3.4)	61 (3.6)	60 (3.4)
(t) Worked closely with other teachers who taught the same grade and/or subject whether or not they were from their school	53 (3.3)	51 (3.4)	56 (3.4)	45 (3.6)
Had opportunities to experience lessons, as their students would, from the textbook/modules they use in their classroom	40 (3.2)	39 (3.0)	49 (3.5)	44 (3.6)
(t) Had opportunities to engage in science investigations/engineering design challenges	43 (3.8)	43 (3.3)	45 (3.2)	37 (3.7)
(t) Had opportunities to apply what they learned to their classroom and then come back and talk about it as part of the professional development	35 (3.5)	34 (3.1)	39 (3.3)	35 (3.4)
(t) Had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction)	33 (3.6)	34 (3.3)	39 (4.2)	33 (3.5)
Had opportunities to rehearse instructional practices during the professional development (i.e., try out, receive feedback, and reflect on those practices)	26 (2.7)	27 (2.5)	31 (3.1)	28 (2.7)

(t) Trend item

† There are no statistically significant differences between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p \geq 0.05$).

a Includes science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent."

Figure 4.5 shows significant differences over time in professional development opportunities for teachers of high-HUS and low-HUS classes. From 2012 to 2018, the gap has narrowed between high-HUS and low-HUS classes taught by teachers whose professional development included the opportunity to examine classroom artifacts. This narrowing appears to be due to decreased prevalence of this opportunity for teachers of high-HUS classes (37 vs. 33 percent) and increased prevalence for teachers of low-HUS classes (23 vs. 33 percent). Similarly, 57 percent of high-HUS classes and 44 percent of low-HUS classes in 2012 were taught by teachers who had opportunities during professional development to engage in science investigations/engineering design challenges, compared to 37 and 43 percent of classes, respectively, in 2018. Interestingly, the comparison of 2018 and 2012 data shows that the opportunity during professional development for teachers of high-HUS and low-HUS classes to work with teachers who taught the same grade and/or subject has reversed. Specifically, 57 percent of high-HUS classes and 44 percent of low-HUS classes were taught by teachers who had this opportunity compared to 45 and 53 percent of classes, respectively, in 2018.



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$)

Figure 4.5

As can be seen in Table 4.31, teachers of high-HUS and low-HUS classes who had attended professional development noted a number of similarities in the emphases of their experiences. For example, teachers in roughly 40–50 percent of classes had professional development opportunities that heavily emphasized deepening their understanding of how science is done, monitoring student understanding, deepening their own science content knowledge, monitoring student understanding during science instruction, and differentiating science instruction to meet the needs of diverse learners. Only one difference in professional development emphasis is apparent when comparing the highest and lowest quartiles of classes. High-HUS classes were more likely than low-HUS classes to be taught by teachers whose professional development heavily emphasized incorporating students' cultural backgrounds into science instruction (34 vs. 14 percent). When looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 4.31
Science Classes Taught by Teachers Whose Professional Development in the Previous Three Years Gave Heavy Emphasis[a] to Various Areas, by HUS Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
Deepening their understanding of how science is done (e.g., developing scientific questions, developing and using models, engaging in argumentation)	48 (3.6)	48 (3.9)	54 (2.9)	46 (4.3)
(t) Deepening their own science content knowledge	46 (3.1)	40 (3.5)	49 (3.0)	46 (3.7)
(t) Monitoring student understanding during science instruction	43 (2.7)	45 (3.5)	46 (4.0)	45 (4.0)
Differentiating science instruction to meet the needs of diverse learners	38 (3.5)	43 (3.1)	44 (3.8)	45 (3.6)
(t) Finding out what students think or already know prior to instruction on a topic	33 (2.7)	38 (3.0)	40 (3.8)	37 (3.8)
Learning how to provide science instruction that integrates engineering, mathematics, and/or computer science	38 (3.5)	39 (3.4)	39 (3.4)	35 (4.3)
(t) Learning about difficulties that students may have with particular science ideas	31 (3.3)	29 (3.0)	38 (3.1)	34 (4.1)
Incorporating students' cultural backgrounds into science instruction*	14 (2.0)	17 (2.0)	26 (3.3)	34 (3.5)
(t) Implementing the science textbook/modules to be used in their classroom	31 (3.3)	30 (2.9)	34 (3.3)	30 (3.4)
Deepening their understanding of how engineering is done (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)	30 (3.9)	24 (3.0)	24 (2.4)	23 (3.2)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent."

These items were combined into two composite variables: Extent Professional Development Aligns with Elements of Effective Professional Development and Extent Professional Development Supports Student-Centered Instruction. As can be seen in Table 4.32, there are no significant differences between classes in the highest and lowest HUS quartiles in either of these areas. However, mean scores of approximately 50 indicate that teachers' professional development opportunities, regardless of HUS quartile, were only somewhat aligned with elements of effective professional development and somewhat supportive of student-centered instruction.

Table 4.32
Science Class Mean Scores for Teachers' Professional Development Composites, by HUS Quartile†

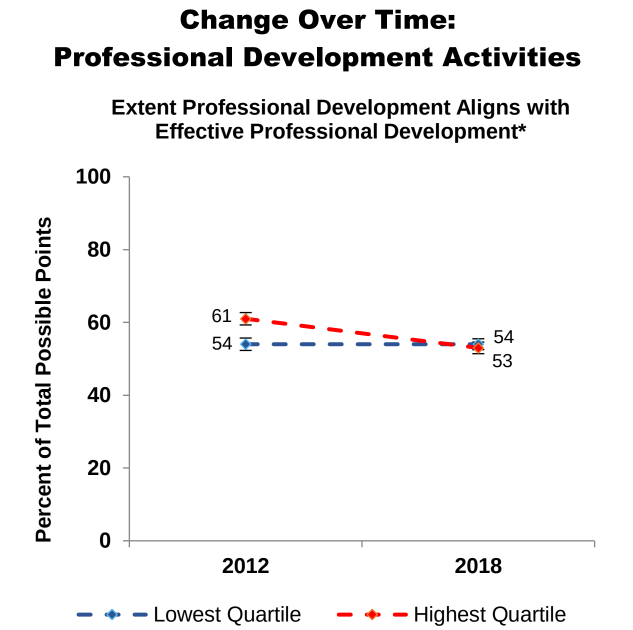
	MEAN SCORE			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Extent Professional Development Aligns With Elements of Effective Professional Development[a]	54 (1.5)	53 (1.5)	57 (1.5)	53 (1.6)
Extent Professional Development Supports Student-Centered Instruction	51 (1.4)	50 (1.4)	52 (1.5)	51 (1.9)

(t) Trend composite

† There are no statistically significant differences between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p \geq 0.05$).

a This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed using only the items in common at both time points. Because there is a significant difference between the two time points for this factor, the data in this table are based on the recomputed composite definition.

Looking specifically at the Extent Professional Development Aligns with Effective Professional Development composite mean scores, there is a narrowing of the gap over time between classes in the lowest quartile and those in the highest quartile (see Figure 4.6).[31] In 2012, the mean score was 61 for classes in the highest quartile and 54 for classes in the lowest quartile, compared to mean scores of 53 and 54, respectively, in 2018.



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$)

Figure 4.6

[31] Too few of the items in the 2018 version of the Extent Professional Development Supports Student-Centered Instruction composite were also asked in 2012 to allow for a comparable composite to be created to examine trends over time.

Summary

Although there are many similarities in the distribution of well-prepared teachers between high-HUS and low-HUS classes, there are also some notable differences. Most high-HUS and low-HUS classes were taught by teachers who had completed the majority of NSTA recommended courses (elementary and middle levels) and/or had a degree in science or science education (secondary level). High-HUS classes were more likely than low-HUS classes to be taught by a teacher from race/ethnicity groups historically underrepresented in STEM, but also more likely to be taught by an inexperienced teacher.

Reform-oriented beliefs and traditional beliefs about teaching and learning were similar between teachers of high-HUS and low-HUS classes. Looking at teacher pedagogical beliefs, there were no differences in reform-oriented beliefs between teachers of classes in the highest and lowest HUS quartiles. However, classes in the highest quartile were more likely than classes in the lowest quartile to be taught by teachers who held the traditional belief that teachers should explain an idea to students before having them consider evidence that relates to the idea.

Although few elementary teachers felt very well prepared to teach any science topic, there were no differences between teachers of classes in the highest and lowest HUS quartiles. At the secondary level, teachers of classes in the highest and lowest quartiles felt equally well prepared to teach all but two science topics: (1) climate and weather and (2) properties of solutions. While few teachers at any grade level felt well prepared to teach engineering, classes in highest quartile were even less likely than classes in lowest quartile to be taught by teachers who felt well prepared to teach engineering concepts.

Teachers in high-HUS and low-HUS classes felt equally well prepared to implement a number of instructional tasks in their classrooms, but a few differences by HUS quartile are apparent. Notably, teachers of high-HUS classes were less likely than teachers of low-HUS classes to encourage participation of all students in science, develop students' conceptual understanding, and develop students' abilities to do science. Further, teachers in high-HUS classes perceived themselves as less well prepared than teachers in low-HUS classes to implement instruction in their most recent unit.

In terms of professional development, nearly three-quarters of classes were taught by teachers who participated in science-focused professional development in the previous three years. There were few differences in the focus or characteristics of this professional development by HUS quartile.

Since 2012, there were statistically significant changes in several areas related to the distribution of well-prepared teachers between high-HUS and low-HUS classes. More high-HUS classes and fewer low-HUS classes were taught by secondary teachers who felt very well prepared to teach a number of science topics between 2012 and 2018, including climate and weather, the periodic table, and properties of matter. There were also differences during this time period related to teachers' professional development opportunities. Fewer high-HUS and more low-HUS classes in 2018 were taught by teachers who participated in more than 35 hours of professional development. Additionally, narrowing of gaps was seen between high-HUS and low-HUS classes taught by teachers whose professional development included opportunities to examine classroom artifacts, engage in science investigations/engineering design challenges, and work closely with other teachers who taught the same grade and/or subject. In each case, the narrowing benefits students in low-HUS classes.

Supportive Context for Learning

The 2018 NSSME+ collected information about a range of contextual factors that may impact effective science instruction. This section presents these data, highlighting the similarities and differences between high- and low-HUS classes.

Factors Affecting Student Opportunity to Learn

Table 4.33 displays the percentages of classes taught by teachers who rated various factors as promoters of effective instruction. Over 60 percent of classes, regardless of HUS quartile, were taught by teachers who rated principal support, the amount of planning time, and current state standards as promoters of effective science instruction. However, teachers of classes in the highest HUS quartile were less likely than those of classes in the lowest HUS quartile to rate students' motivation, interest, and effort in science (61 vs. 71 percent) and students' prior knowledge and skills (51 vs. 63 percent) as factors promoting effective science instruction. Conversely, teachers of classes in the highest quartile were more likely than their counterparts in the lowest quartile to consider state/district testing/accountability policies as promoting effective instruction (41 vs. 30 percent). The 2018 data are not significantly different from the data in 2012.

Table 4.33
Factors Promoting[a] Effective Instruction in Science Classes, by HUS Quartile

	PERCENT OF CLASSES			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Principal support	64 (2.8)	67 (3.1)	71 (3.4)	64 (3.2)
(t) Amount of time for you to plan, individually and with colleagues	62 (2.6)	61 (3.6)	64 (3.4)	64 (3.7)
(t) Students' motivation, interest, and effort in science*	71 (2.3)	72 (2.7)	65 (3.4)	61 (3.5)
(t) Current state standards	61 (2.8)	64 (2.9)	64 (3.0)	61 (3.2)
(t) Amount of time available for your professional development	48 (3.2)	46 (3.1)	47 (3.7)	52 (3.6)
Students' prior knowledge and skills*	63 (2.6)	60 (3.0)	59 (3.0)	51 (4.3)
(t) Pacing guides	54 (2.8)	50 (3.9)	57 (3.5)	49 (3.5)
(t) College entrance requirements[b]	55 (4.3)	50 (4.0)	59 (4.6)	47 (5.6)
Amount of instructional time devoted to science[c]	52 (4.8)	47 (6.1)	51 (4.6)	46 (4.3)
(t) Teacher evaluation policies	41 (3.0)	38 (3.2)	41 (3.1)	41 (4.1)
(t) State/district/diocese testing/accountability policies*,[d]	30 (2.9)	32 (2.9)	31 (2.8)	41 (3.6)
(t) Parent/guardian expectations and involvement	39 (2.6)	46 (2.9)	37 (2.6)	37 (2.6)
(t) Textbook/module selection policies	37 (3.4)	32 (3.5)	38 (2.9)	34 (3.4)

(t) Trend item

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes science teachers indicating 4 or 5 on a five-point scale ranging from 1 "inhibits effective instruction" to 5 "promotes effective instruction."

[b] This item was presented only to high school teachers.

[c] This item was presented only to elementary school teachers.

[d] This item was presented only to teachers in public and Catholic schools.

Three composites were created from these items: (1) Extent to Which School Support Promotes Effective Instruction; (2) Extent to Which the Policy Environment Promotes Effective Instruction; and (3) Extent to Which Stakeholders Promote Effective Instruction. As can be seen in Table 4.34, each of these factors appears to have a moderate influence on science instruction. There are no significant differences between the highest and lowest quartiles for the school support or policy environment composites. However, there is a significant difference between the highest and lowest quartiles for the Extent to Which Stakeholders Promote Effective Instruction composite (mean scores of 61 vs. 68). When looking at trends over time, the 2018 data for the Extent to Which School Support Promotes Effective Instruction and Extent to Which the Policy Environment Promotes Effective Instruction composites are not significantly different than in 2012.[32]

Table 4.34
Science Class Mean Scores for Factors Affecting Instruction Composites, by HUS Quartile

	MEAN SCORE			
	LOWEST QUARTILE	SECOND QUARTILE	THIRD QUARTILE	HIGHEST QUARTILE
(t) Extent to Which School Support Promotes Effective Instruction	64 (1.8)	64 (2.0)	66 (2.1)	66 (2.6)
Extent to Which Stakeholders Promote Effective Instruction*	68 (1.1)	68 (1.5)	65 (1.9)	61 (2.6)
(t) Extent to Which the Policy Environment Promotes Effective Instruction[a]	62 (1.4)	61 (1.2)	63 (1.3)	61 (1.5)

(t) Trend composite

* There is a statistically significant difference between classes in the lowest quartile and those in the highest quartile (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed for 2012 using the 2018 definition.

Summary

Overall, the 2018 data indicate that the school climate, in terms of school support, policies, and stakeholders, was generally supportive of effective science instruction, regardless of HUS quartile. Factors seen as promoting effective instruction in a majority of science classes across quartiles included principal support, planning time, and current state standards. However, there are also significant differences between high-HUS and low-HUS classes on a handful of items (e.g., students' motivation, interest, and effort in science; students' prior knowledge and skills; state/district/diocese testing/accountability policies), with teachers of high-HUS classes consistently less likely to view these factors as promoting effective instruction. Since 2012, contextual factors affecting students' opportunity to learn in high-HUS and low-HUS classes have remained consistent.

[32] Too few items in the 2018 version of the Extent to Which Stakeholders Promote Effective Instruction composite were also asked in 2012; thus, trend data are not available to report.

Prior Achievement Level

For this class-level factor, teachers were asked to indicate the prior achievement level of students in a randomly selected class, relative to other students in the school. Classes were classified into 1 of 3 categories: mostly high-prior-achieving (HPA) students, average/mixed-prior-achieving students, and mostly low-prior-achieving (LPA) students. As can be seen in Table 5.1, nearly three-fourths of K–12 science classes were composed of mostly average or mixed levels of prior achievement. Classes of mostly HPA and LPA students each made up 12–14 percent of all science classes. This chapter presents data by prior achievement group, noting differences between classes of LPA students and classes of HPA students.

Table 5.1
Percentage of Classes in Each Prior Achievement Group[(t),†]

	PERCENT OF CLASSES
Mostly High	12 (0.8)
Average/Mixed	73 (0.9)
Mostly Low	14 (0.7)

(t) Trend item

† There are no statistically significant differences between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p \geq 0.05$).

Nature of Science Instruction

As described in previous chapters, the 2018 NSSME+ collected a large amount of data about science instruction. This section presents these data, highlighting the similarities and differences between classes of mostly LPA and HPA students.

Time Spent on Various Subjects in Elementary Grades

Table 5.2 shows the average number of minutes per day typically spent on science, reading/language arts, mathematics, and social studies in elementary grades self-contained classes that cover all four subjects. Classes of LPA and HPA students spent an average of 22 minutes per day on science instruction. However, time spent on science instruction was substantially less than time spent on reading/language arts or mathematics. The 2018 science data are not different from the 2012 science data.

Table 5.2
Average Number of Minutes Per Day Spent Teaching Each Subject in Elementary Grades Self-Contained Classes,[a] by Prior Achievement

	NUMBER OF MINUTES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Reading/Language Arts	78 (6.0)	87 (1.6)	93 (4.9)
(t) Mathematics*	51 (3.5)	58 (0.9)	64 (2.5)
(t) Science	22 (2.0)	19 (0.5)	22 (1.5)
(t) Social Studies	18 (1.7)	17 (0.4)	19 (1.0)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

a Includes only self-contained elementary teachers who indicated they teach reading/language arts, mathematics, science, and social studies to one class of students.

Course-Taking Opportunities in High School

At the high school level, teachers were asked to provide information about a randomly selected class, including the course type, which allows for an estimate of the percentage of science courses of each type. In 2018, classes of LPA students were much more likely than classes of HPA students to be non-college prep courses (58 vs. 10 percent) and much less likely to be advanced science, such as those that might qualify for college credit (7 vs. 36 percent). These data are not significantly different from the 2012 data.

Table 5.3

Prevalence of High School Science Courses, by Prior Achievement(t)

	PERCENT OF CLASSES*		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
Non-college prep	10 (2.2)	30 (2.0)	58 (6.3)
1st year biology	20 (2.9)	25 (2.0)	16 (3.4)
1st year multi-discipline science courses	4 (1.3)	6 (1.0)	7 (2.1)
1st year chemistry	16 (1.5)	17 (1.5)	6 (1.2)
1st year physics	11 (1.5)	8 (1.2)	4 (1.2)
1st year environmental science	2 (0.7)	3 (1.1)	2 (1.0)
1st year Earth/space science	2 (0.8)	3 (0.8)	0 --§
Advanced science courses	36 (3.1)	9 (1.3)	7 (6.5)

(t) Trend item

* There is a statistically significant difference in the distribution between classes of mostly LPA students and those of mostly HPA students (Chi-square test of independence, $p < 0.05$).

Teachers' Perceptions of Their Decision-Making Autonomy

The survey asked teachers about the extent to which they had control over a number of curricular and instructional decisions. As can be seen in Table 5.4, teachers' perceptions of control over instructional decisions varied according to the prior achievement of the class. For example, teachers of classes with low levels of prior achievement were less likely than their counterparts in classes with high levels of prior achievement to feel they had strong control over determining the amount of homework to be assigned (66 vs. 78 percent), selecting teaching techniques (48 vs. 74 percent), and choosing criteria for grading student performance (43 vs. 59 percent).

A similar pattern can be seen in teachers' perceptions of control over curricular decisions. Classes of LPA students were less likely than classes of HPA students to be taught by teachers who considered themselves to have strong control over selecting the sequence in which topics are covered (30 vs. 51 percent), selecting content, topics, and skills to be taught (20 vs. 29 percent), determining course goals and objectives (19 vs. 34 percent), and selecting curriculum materials (14 vs. 39 percent). When looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 5.4
Science Classes in Which Teachers Felt Strong Control Over Various Curricular and Instructional Decisions, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Determining the amount of homework to be assigned*	78 (2.8)	64 (1.9)	66 (3.9)
(t) Selecting teaching techniques*	74 (3.0)	55 (1.9)	48 (4.8)
(t) Choosing criteria for grading student performance*	59 (3.0)	47 (1.9)	43 (4.0)
Selecting the sequence in which topics are covered*	51 (3.3)	36 (1.8)	30 (3.9)
Determining the amount of instructional time to spend on each topic*	49 (3.2)	30 (1.8)	30 (4.7)
(t) Selecting content, topics, and skills to be taught*	29 (3.2)	21 (2.0)	20 (3.3)
(t) Determining course goals and objectives*	34 (3.3)	25 (2.0)	19 (3.7)
(t) Selecting curriculum materials (e.g., textbooks/online courses)*	39 (3.3)	22 (1.8)	14 (2.6)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

These items were combined into Curriculum Control and Pedagogy Control composite variables. The mean scores, shown in Table 5.5, indicate that teachers of classes across prior achievement levels were more likely to feel strong control over pedagogical decisions than over curricular decisions. Further, teachers of classes with low levels of prior achievement felt less control over decisions related to curriculum and pedagogy than teachers of classes with high levels of prior achievement. These data are not significantly different from the data in 2012.

Table 5.5
Science Class Mean Scores for Curriculum Control and Pedagogy Control Composites, by Prior Achievement

	MEAN SCORE		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Curriculum Control*,[a]	65 (1.9)	53 (1.4)	46 (2.7)
(t) Pedagogy Control*	90 (1.0)	82 (0.9)	79 (2.2)

(t) Trend composite

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed for 2018 using the 2012 definition. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Instructional Objectives

The survey provided a list of possible instructional objectives and asked teachers how much emphasis each would receive in the targeted class. As can be seen in Table 5.6, there are many differences between classes of LPA students and classes of HPA students. Although understanding science concepts was emphasized in over half of all classes, it was significantly less likely to be emphasized in classes of LPA students than HPA students (56 vs. 81 percent). Classes of LPA students were also less likely than classes of HPA students to heavily emphasize learning how to do science (26 vs. 45 percent), increasing student interest in science/engineering (23 vs. 40 percent), developing students' confidence in pursuing careers in science/engineering (20 vs. 42

percent), and learning about real-life applications of science/engineering (19 vs. 33 percent). These same differences were present in 2012.

Table 5.6
Science Classes With Heavy Emphasis on Various Instructional Objectives, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Understanding science concepts*	81 (2.4)	58 (1.3)	56 (3.6)
Learning science vocabulary and/or facts	36 (2.8)	29 (1.3)	33 (3.0)
Learning how to do science (develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)*	45 (2.6)	34 (1.5)	26 (2.3)
(t) Increasing students' interest in science/engineering*	40 (2.4)	29 (1.6)	23 (2.7)
(t) Learning test-taking skills/strategies	27 (2.1)	20 (1.1)	22 (2.2)
Developing students' confidence that they can successfully pursue careers in science/engineering *	42 (2.7)	26 (1.5)	20 (2.6)
(t) Learning about real-life applications of science/engineering*	33 (2.6)	23 (1.5)	19 (2.0)
Learning how to do engineering (e.g., identify criteria and constraints, design solutions, optimize solutions)	9 (2.0)	8 (1.3)	5 (1.4)
Learning about different fields of science/engineering*	9 (1.5)	8 (1.2)	4 (1.1)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

The objectives related to reform-oriented instruction were combined into a composite variable. As can be seen in Table 5.7, science classes with low levels of prior achievement were, on average, less likely than those with high levels of prior achievement to emphasize reform-oriented instructional objectives (mean scores of 57 vs. 68). The 2018 data are not significantly different from the 2012 data.

Table 5.7
Science Class Mean Scores for the Reform-Oriented Instructional Objectives Composite,[a] by Prior Achievement

	MEAN SCORE
Mostly High	68 (0.9)
Average/Mixed	63 (0.6)
Mostly Low	57 (1.3)

(t) Trend composite

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed using only the items in common at both time points. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Class Activities

As can be seen in Table 5.8, large percentages of science classes, regardless of prior achievement level, included the teacher explaining science ideas to the whole class at least once a week. Additionally, more than three-quarters of all classes included engaging the whole class in discussions at least once a week. However, differences between class achievement levels are also present. Classes of LPA students were less likely than classes of HPA students to have students work in small groups (76 vs. 84 percent), do hands-on laboratory activities (45 vs. 69 percent) and engage the class in project-based learning activities (21 vs. 31 percent). Conversely, classes of LPA students were more likely than classes of HPA students to focus on literacy skills (51 vs. 41 percent).

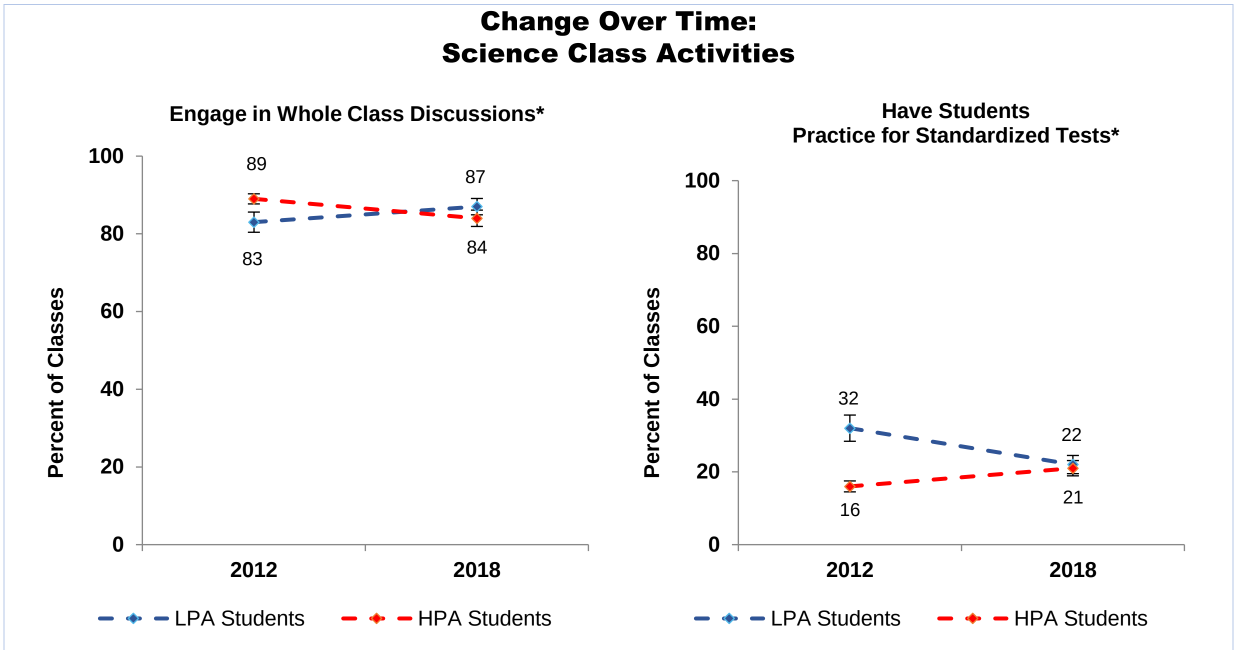
Table 5.8
Science Classes in Which Teachers Used Various Activities at Least Once a Week, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Explain science ideas to the whole class	92 (1.4)	88 (1.3)	90 (2.0)
(t) Engage the whole class in discussions	84 (2.1)	87 (0.7)	87 (2.1)
(t) Have students work in small groups*	84 (1.9)	79 (1.3)	76 (2.6)
(t) Focus on literacy skills (e.g., informational reading or writing strategies)*	41 (2.6)	51 (1.2)	51 (3.4)
(t) Have students do hands-on/laboratory activities*	69 (2.5)	59 (1.4)	45 (3.9)
(t) Have students read from a textbook, module, or other material in class, either aloud or to themselves	29 (2.6)	35 (1.4)	35 (2.9)
(t) Have students write their reflections (e.g., in their journals, on exit tickets) in class or for homework	33 (2.2)	42 (1.4)	34 (3.3)
(t) Have students practice for standardized tests	21 (2.1)	18 (1.0)	22 (2.5)
(t) Engage the class in project-based learning (PBL) activities*	31 (2.3)	30 (1.5)	21 (2.9)
Use flipped instruction (have students watch lectures/demonstrations outside of class to prepare for in-class activities)	17 (2.3)	10 (0.8)	11 (2.0)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

With the exceptions of having students engage in whole class discussions and practice for standardized tests, the differences in class activities between classes of LPA students and classes of HPA students have not changed between the two iterations of the study. Further, in both of these cases, the gap has narrowed. In 2012, 83 percent of LPA classes and 89 percent of HPA classes included engaging in whole class discussions, compared to 87 and 84 percent of classes, respectively, in 2018 (See Figure 5.1). Similarly, 32 percent of classes of LPA students and 16 percent of classes of HPA students practiced for standardized tests at least once a week in 2012 compared to 22 and 21 percent of classes, respectively, in 2018.



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

Figure 5.1

As described in previous chapters, the 2018 survey also asked teachers how often they engage students in aspects of the science practices. As can be seen in Table 5.9, there are many differences between classes of LPA and HPA students, all of which favored HPA students. For example, classes of LPA students were less likely than classes of HPA students to generate scientific questions (36 vs. 45 percent), organize and represent data using tables, charts, or graphs in order to facilitate analysis of the data (34 vs. 57 percent), make and support claims with evidence (32 vs. 51 percent) or conduct a scientific investigation (30 vs. 54 percent). Classes of LPA students were also less likely than classes of HPA students to analyze data using grade-appropriate methods in order to identify patterns, trends, or relationships (26 vs. 48 percent), determine what data would need to be collected in order to answer a scientific question (25 vs. 42 percent), and use multiple sources of evidence to develop an explanation (25 vs. 35 percent). This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 5.9
Science Classes in Which Students Engaged in Various Aspects of Science Practices at Least Once a Week, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
Generate scientific questions*	45 (2.5)	38 (1.5)	36 (3.5)
Organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data*	57 (2.4)	43 (1.4)	34 (2.7)
Make and support claims with evidence*	51 (2.6)	40 (1.4)	32 (3.2)
Conduct a scientific investigation*	54 (2.2)	42 (1.8)	30 (3.0)
Analyze data using grade-appropriate methods in order to identify patterns, trends, or relationships*	48 (2.8)	35 (1.4)	26 (2.3)
Determine what data would need to be collected in order to answer a scientific question*	42 (2.4)	34 (1.5)	25 (2.9)
Use multiple sources of evidence to develop an explanation*	35 (2.9)	30 (1.4)	25 (2.9)
Develop procedures for a scientific investigation to answer a scientific question*	39 (2.5)	31 (1.5)	22 (3.0)
Develop scientific models—physical, graphical, or mathematical representations of real-world phenomena*	34 (2.4)	25 (1.3)	21 (2.2)
Revise their explanations based on additional evidence*	32 (2.7)	24 (1.5)	21 (2.6)
Determine whether or not a question is scientific*	31 (2.5)	23 (1.2)	21 (2.4)
Compare data from multiple trials or across student groups for consistency in order to identify potential sources of error or inconsistencies in the data*	37 (3.0)	25 (1.6)	19 (2.0)
Use data and reasoning to defend, verbally or in writing, a claim or refute alternative scientific claims*	28 (1.9)	21 (1.1)	19 (3.0)
Summarize patterns, similarities, and differences in scientific information obtained from multiple sources*	29 (2.2)	22 (1.5)	18 (2.4)
Select and use grade-appropriate mathematical and/or statistical techniques to analyze data*	29 (2.4)	19 (1.3)	16 (2.2)
Evaluate the strengths and weaknesses of competing scientific explanations	19 (1.9)	15 (1.0)	16 (2.4)
Pose questions that elicit relevant details about the important aspects of a scientific argument*	24 (1.9)	18 (1.1)	15 (2.0)
Consider how missing data or measurement error can affect the interpretation of data*	28 (2.1)	18 (1.3)	14 (1.8)
Identify the strengths and limitations of a scientific model—in terms of accuracy, clarity, generalizability, accessibility to others, strength of evidence supporting it*	22 (2.0)	16 (1.3)	13 (2.2)
Construct a persuasive case, verbally or in writing, for the best scientific model or explanation for a real-world phenomenon*	20 (2.1)	11 (0.8)	13 (1.9)
Use mathematical and/or computational models to generate data to support a scientific claim*	28 (2.4)	16 (1.1)	12 (2.0)
Evaluate the credibility of scientific information—e.g., its reliability, validity, consistency, logical coherence, lack of bias, or methodological strengths and weaknesses*	23 (2.0)	13 (0.9)	12 (2.2)
Determine what details about an investigation might persuade a targeted audience about a scientific claim*	17 (1.8)	13 (0.9)	11 (2.0)

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

Table 5.10 shows the mean scores for Engaging Students in the Practices of Science Composite formed from these items. The mean scores indicate that students, regardless of prior achievement, were only moderately likely to engage in the practices of science. Further, classes of LPA students were less likely than classes of HPA students to engage in these practices (mean scores of 42 vs. 51).

Table 5.10
Science Class Mean Scores for Engaging Students in Practices of Science Composite, by Prior Achievement

	MEAN SCORE*
Mostly High	51 (1.1)
Average/Mixed	43 (0.5)
Mostly Low	42 (1.5)

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

The survey also asked how often students in the randomly selected class were required to take assessments the teacher did not develop, such as state or district benchmark assessments. As can be seen in Table 5.11, there were no differences in the frequency of testing by prior achievement. These data are not significantly different from the data in 2012.

Table 5.11
Science Classes Required to Take External Assessments Two or More Times Per Year, by Prior Achievement†

	MEAN SCORE
Mostly High	35 (3.2)
Average/Mixed	29 (1.5)
Mostly Low	39 (4.2)

(t) Trend composite

† There is no statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p \geq 0.05$).

Summary

A number of aspects of science instruction were relatively similar between classes of LPA and HPA students in 2018, but there are also notable differences. At the elementary level, students, regardless of prior achievement level, spent little time on science instruction per day. In terms of course-taking opportunities at the high school level, LPA students were more likely than HPA students to be enrolled in non-college prep courses and less likely to be enrolled in advanced science courses.

Data about teachers' perceptions of control and emphasis on instructional objectives also reflect differences between science classes by prior achievement level. For example, teachers of classes of LPA students felt less control over decisions related to curriculum and pedagogy than their counterparts teaching classes of HPA students. In addition, classes of LPA students were less likely than classes of HPA students to emphasize reform-oriented instructional objectives (e.g., understanding science concepts, learning how to do science).

Several instructional activities were prominent in science classes regardless of the prior achievement level of the class, including the teacher explaining ideas and whole class discussions. However, classes of LPA students were less likely than classes of HPA students to work in small groups, do hands-on/laboratory activities, or engage in project-based learning activities. In terms of students' engagement in the science practices, there were a number of differences (e.g., generating scientific questions and organizing and/or representing data using tables, charts, or graphs in order to facilitate analysis of the data), each of which was less common in classes of LPA students than classes of HPA students.

Since 2012, the nature of science instruction provided in classes of LPA and HPA students has remained largely consistent. Two notable differences are related to the use of instructional activities in a given class. From 2012 to 2018, the gap between classes of LPA students and HPA students engaging in whole class discussions narrowed, a change that advantaged classes of LPA students. Similarly, the gap between classes of LPA students and HPA students practicing for standardized tests narrowed, due in large part to the decreased emphasis on this activity over time in classes of LPA students.

Material Resources

The 2018 NSSME+ collected information about material resources for instruction as well as teachers' perceptions of the adequacy of these resources. This section provides data about the distribution and adequacy of material resources by the prior achievement of level of science classes.

Instructional Materials

In 2018, roughly two-thirds of science classes, regardless of prior achievement level, had instructional materials designated for use by the district (see Table 5.12). Commercially published textbooks were by far the most frequently designated type of material. Other materials, such as commercially published kits/modules and lessons or resources from websites, were less commonly designated. However, classes of LPA students were less likely than classes of HPA students to have lessons or resources from websites that are free (20 vs 33 percent) designated. This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 5.12
Types of Instructional Materials Designated for Science Classes, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
District Designates Instructional Materials			
No	38 (2.7)	33 (1.8)	31 (3.0)
Yes	62 (2.7)	67 (1.8)	69 (3.0)
Types of Designated Instructional Materials[a]			
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	86 (3.1)	76 (1.9)	77 (4.6)
Commercially published kits/modules (printed or electronic)	29 (3.4)	44 (2.2)	38 (3.3)
State, county, district, or diocese-developed units or lessons	38 (3.8)	37 (1.7)	37 (4.3)
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)	31 (3.7)	35 (1.8)	24 (3.5)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)*	33 (2.6)	21 (1.3)	20 (3.1)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)	14 (2.5)	10 (0.9)	12 (2.1)

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

[a] Only science classes for which instructional materials are designated by the state, district, or diocese are included in these analyses.

Regardless of whether instructional materials had been designated for their class, teachers were asked how often instruction was based on various types of materials. Although units or lessons created by teachers were the most commonly used material across classes (see Table 5.13), they were less likely to be used in classes of LPA students than classes of HPA students (57 vs. 84 percent). Additionally, units or lessons collected from other sources (e.g., conferences, journals, colleagues) were less likely to be used in classes of LPA students than classes of HPA students (34 vs. 51 percent). This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 5.13
Science Classes Basing Instruction on Various Types of Instructional Materials at Least Once a Week, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
Units or lessons you created (either by yourself or with others)*	84 (2.2)	61 (1.7)	57 (3.7)
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	46 (2.7)	42 (1.5)	43 (3.2)
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)	26 (2.6)	40 (1.6)	34 (3.2)
Units or lessons you collected from any other source (e.g., conferences, journals, colleagues, university or museum partners)*	51 (2.4)	35 (1.5)	34 (3.0)
State, county, district, or diocese-developed units or lessons	19 (2.2)	26 (1.7)	25 (3.1)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	31 (2.3)	26 (1.5)	26 (3.3)
Commercially published kits/modules (printed or electronic)	23 (2.2)	26 (1.5)	24 (3.2)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)	9 (1.3)	8 (0.6)	7 (1.6)

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

Teachers who used commercially published textbooks were asked provide information about the textbook used most often in the class, including publication year. As can be seen in Table 5.14, the majority of classes, regardless of prior achievement level, used textbooks that were six or more years old. However, classes of LPA students were even more likely than classes of HPA students to use outdated textbooks.

Table 5.14
Age of Science Textbooks in 2018, by Prior Achievement(t)

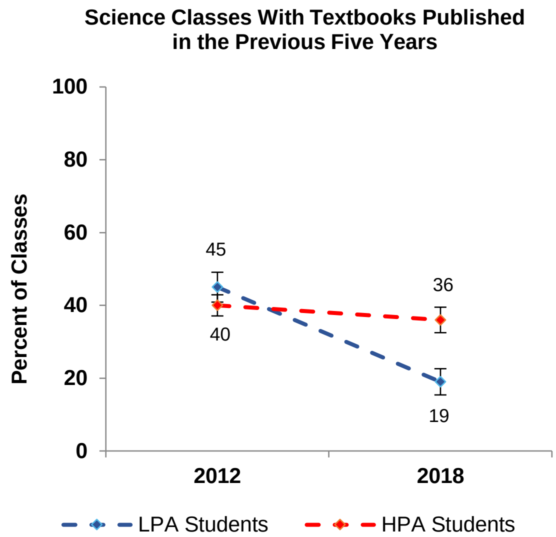
	PERCENT OF CLASSES*		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
5 or fewer years	36 (3.5)	28 (2.3)	19 (3.6)
6 or more years	64 (3.5)	72 (2.3)	81 (3.6)

(t) Trend item

* There is a statistically significant difference in the distribution between classes of mostly LPA students and those of mostly HPA students (Chi-square test of independence, $p < 0.05$).

Since 2012, the gap between classes of LPA students and HPA students using textbooks published in the previous five years has widened (see Figure 5.2). This widening appears to be due to a large decrease in the percentage of classes of LPA students using newer textbooks and only a slight decrease in classes of HPA students. Specifically, in 2012, 45 percent of classes of LPA students and 40 percent of classes of HPA students used newer textbooks, compared to 19 and 36 percent of classes, respectively, in 2018.

Change Over Time:
Age of Textbooks



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

Figure 5.2

Facilities and Equipment

The survey also asked teachers about the availability of resources for science instruction. As can be seen in Table 5.15, nearly all classes, regardless of prior achievement level, had access to projection devices. Although other resources were also fairly common, classes of LPA students were less likely than classes of HPA students to have access to balances (85 vs. 95 percent), microscopes (74 vs. 88 percent), and probes for collecting data (51 vs. 73 percent). The differences in the availability of these technologies according to prior achievement level have not changed significantly since 2012.

Table 5.15
Availability[a] of Instructional Resources in Science Classes, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
Projection devices (e.g., Smartboard, document camera, LCD projector)	99 (0.6)	98 (0.6)	97 (1.3)
Balances (e.g., pan, triple beam, digital scale)*	95 (1.5)	87 (1.2)	85 (3.4)
(t) Microscopes*	88 (2.4)	71 (1.6)	74 (4.1)
(t) Probes for collecting data (e.g., motion sensors, temperature probes)*	73 (3.1)	54 (2.1)	51 (4.3)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

a Includes only those teachers indicating the resource is always available in their classroom or available upon request.

Additionally, teachers were asked about the availability of laboratory facilities for science instruction (see Table 5.16). In general, laboratory facilities were readily available to science classes across prior achievement levels. However, classes of LPA students were less likely than classes of HPA students to have access to faucets and sinks (87 vs. 94 percent), gas for burners (72 vs. 91 percent), and fume hoods (64 vs. 88 percent). The 2018 data are not significantly different from the 2012 data.

Table 5.16
Availability[a] of Laboratory Facilities in Science Classes, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Electric outlets	98 (1.1)	95 (0.7)	93 (2.1)
(t) Faucets and sinks*	94 (1.5)	86 (1.3)	87 (2.3)
(t) Gas for burners*,b	91 (1.9)	86 (2.0)	72 (7.3)
(t) Fume hoods*,b	88 (2.2)	83 (1.8)	64 (7.9)
(t) Lab tables*	80 (3.0)	52 (2.1)	57 (4.0)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

a Includes only those science teachers indicating the resource is either located in the classroom or available in another room.

b This item was presented only to high school teachers.

Access to appropriate and adequate resources is another important factor in students' opportunity to learn. Across all categories (facilities, instructional technology, equipment, consumable supplies), teachers of classes with low levels of prior achievement were much less likely than teachers of classes with high levels of prior achievement to rate their resources as adequate (see Table 5.17). The same inequities between classes were present in 2012.

Table 5.17
Adequacy[a] of Resources for Science Instruction, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Facilities (e.g., lab tables, electric outlets, faucets and sinks)*	69 (3.1)	50 (1.6)	47 (4.1)
(t) Instructional technology (e.g., calculators, computers, probes/sensors)*	71 (2.8)	56 (2.0)	46 (4.6)
(t) Equipment (e.g., thermometers, magnifying glasses, microscopes, beakers, photogate timers, Bunsen burners)*	72 (2.8)	50 (1.7)	44 (3.7)
(t) Consumable supplies (e.g., chemicals, living organisms, batteries)*	60 (3.2)	41 (1.8)	34 (4.2)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

a Includes science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not adequate" to 5 "adequate."

These items were combined into a composite variable named Adequacy of Resources for Science Instruction. As shown in Table 5.18, teachers of classes with low levels of prior achievement had less positive views about their resources compared to teachers of classes with high levels of prior achievement (mean scores of 54 vs. 74). The 2018 data are not significantly different from the 2012 data.

Table 5.18
Science Class Mean Scores for the Adequacy of Resources for Instruction Composite, by Prior Achievement(t)

	MEAN SCORE*
Mostly High	74 (1.6)
Average/Mixed	60 (1.1)
Mostly Low	54 (2.5)

(t) Trend composite

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

Summary

The distribution and use of material resources for science instruction between classes of LPA and HPA students are similar in some ways and different in others. Commercially published textbooks were the most commonly designated instructional material, regardless of the prior achievement level of the class. Units or lessons developed by teachers were the most commonly used instructional materials across achievement levels, but they were less likely to be used in classes of LPA students than classes of HPA students. The majority of classes, regardless of prior achievement level, used textbooks that were six or more years old. However, classes of LPA students were even more likely than classes of HPA students to use outdated textbooks.

There are also disparities related to the availability of resources and teachers' perceptions of the adequacy of these resources. Teachers of classes of LPA students were less likely than teachers of classes of HPA students to have access to a number of instructional resources (e.g., balances, microscopes) and laboratory facilities (e.g., gas for burners, fume hoods). Teachers of classes of LPA students also had less positive views about the resources available to them than their counterparts teaching classes of HPA students.

Because questions on the survey in this topic area were substantively different in 2018 than in 2012, opportunities for trend analysis were limited. However, there is one significant change since 2012. The difference between classes of LPA and HPA students using textbooks published in the previous five years has widened, due in large part to a large decrease in the percentage of classes of LPA students using newer textbooks and only a slight decrease in classes of HPA students.

Well-Prepared Teachers

As described in previous chapters, the 2018 NSSME+ collected data on a number of indicators of teacher preparedness. The distribution of well-prepared teachers among classes with different levels of prior achievement is described in the following sections.

Teacher Characteristics and Preparation

As can be seen in Table 5.19 about three-fourths of classes at the elementary and middle grades levels, regardless of prior achievement level, were taught by teachers who had completed the majority of NSTA-recommended courses. However, at the secondary level, classes of LPA students were less likely than classes of HPA students to be taught by teachers with a degree in science or science education (69 vs. 85 percent) or 3 or more advanced courses in the subject (43 vs. 72 percent). Further, across grade levels, classes of LPA students were more likely than classes of HPA students to be taught by teachers with five or fewer years of experience teaching science (40 vs. 27 percent). Taken together, these data suggest that classes of LPA students and classes of HPA students differed in the extent to which they had access to well-prepared teachers.

Table 5.19
Teacher Characteristics, by Prior Achievement

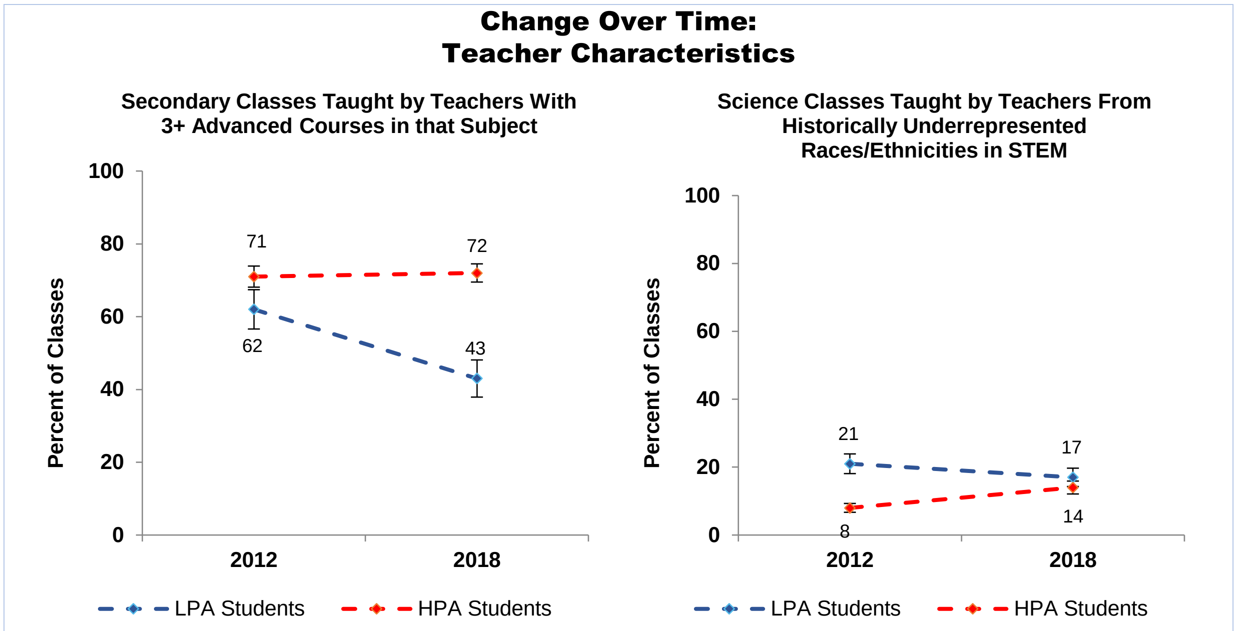
	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Teacher completed all or all-but-one of the NSTA recommended courses[a]	80 (4.6)	72 (1.5)	78 (3.6)
(t) Secondary teacher with a degree in science or science education*	85 (2.1)	76 (2.0)	69 (4.6)
(t) Secondary teacher with a degree or 3+ advanced courses in the subject*	72 (2.5)	61 (2.2)	43 (5.1)
(t) Teacher has 0–5 years of experience teaching science*	27 (2.6)	33 (1.5)	40 (3.1)
Teacher with job experience in science or engineering	25 (2.5)	14 (1.0)	22 (4.1)
(t) Teacher from historically underrepresented race/ethnicity group	14 (1.9)	16 (1.4)	17 (2.7)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

[a] NSTA only has recommended courses for elementary and middle school grades teachers; high school teachers are not included.

Over time, the gap between classes of LPA and HPA students taught by high school teachers with three or more advanced courses in the subject has widened (see Figure 5.3). In 2012, 62 percent of classes of LPA students and 71 percent of HPA students were taught by teachers with this level of course taking background. By 2018, these percentages changed to 43 and 72 percent, respectively. Conversely, the gap between classes of LPA and HPA students taught by teachers from historically underrepresented races/ethnicities in STEM has narrowed. This narrowing of the gap is likely due to a slight decrease of these teachers in classes of LPA students (21 vs. 17 percent) and increase in classes of HPA students (8 vs. 14 percent) from 2012 to 2018.



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

Figure 5.3

Teacher Pedagogical Beliefs

Because beliefs are important mediators of behaviors, teachers were asked about their beliefs regarding effective teaching and learning. As can be seen in Table 5.20, large percentages of teachers tended to hold a number of reform-oriented beliefs, regardless of prior achievement level of the class. For example, over 90 percent of teachers agreed that students learn best when instruction is connected to their everyday lives, students should learn science by doing science, and that most class periods should provide opportunities for students to share their thinking and reasoning. Additionally, although large percentages of teachers agreed that teachers should ask students to support their conclusions about a science concept with evidence, this belief was slightly less prevalent among teachers of classes of LPA students than teachers of classes of HPA students (92 vs. 98 percent).

Despite having strongly held reform-oriented beliefs, teachers of LPA and HPA students also held a number of traditional beliefs. For example, at least 60 percent of teachers agreed that students should be provided with definitions for new scientific vocabulary that will be used at the beginning of instruction on a science idea. However, this belief was more strongly held by teachers of classes of LPA students than teachers of classes of HPA students (73 vs. 60 percent). Over half of teachers, regardless of prior achievement level of the class, also agreed that hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned and that students learn science best in classes with students of similar abilities.

Table 5.20
Science Classes in Which Teachers Agreed[a] With Various Statements About Teaching and Learning, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
Reform-Oriented Beliefs			
Students learn best when instruction is connected to their everyday lives.	97 (1.0)	96 (0.6)	95 (1.8)
Teachers should ask students to support their conclusions about a science concept with evidence.*	98 (0.9)	97 (0.7)	92 (2.4)
Students should learn science by doing science (e.g., developing scientific questions; designing and conducting investigations; analyzing data; developing models, explanations, and scientific arguments).	97 (0.7)	95 (0.8)	92 (2.3)
(t) Most class periods should provide opportunities for students to share their thinking and reasoning.	92 (1.7)	95 (0.8)	91 (2.3)
Most class periods should provide opportunities for students to apply scientific ideas to real-world contexts.	94 (1.0)	93 (1.0)	89 (2.5)
(t) It is better for science instruction to focus on ideas in depth, even if that means covering fewer topics.	76 (2.8)	76 (1.7)	75 (4.3)
Traditional Beliefs			
(t) At the beginning of instruction on a science idea, students should be provided with definitions for new scientific vocabulary that will be used.*	60 (3.7)	73 (2.0)	73 (3.7)
(t) Hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned.	51 (3.3)	54 (1.7)	56 (3.3)
(t) Students learn science best in classes with students of similar abilities.	54 (3.3)	34 (1.7)	55 (4.1)
(t) Teachers should explain an idea to students before having them consider evidence that relates to the idea.	33 (3.1)	32 (1.6)	36 (3.8)

(t) Trend item

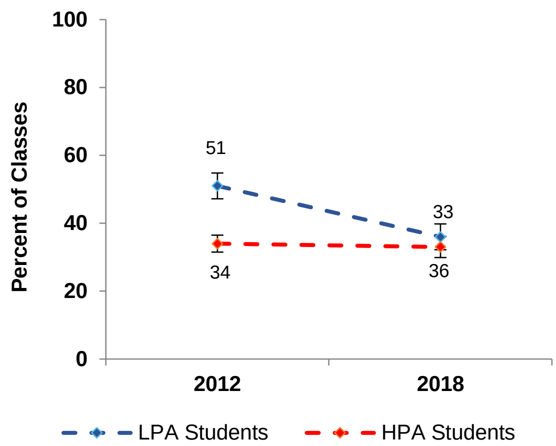
* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes teachers indicating “strongly agree” or “agree” on a five-point scale ranging from 1 “strongly disagree” to 5 “strongly agree.”

Since 2012, the gap between classes of LPA and HPA students taught by teachers who agree that teachers should explain an idea to students before having them consider evidence that relates to the idea has narrowed (see Figure 5.4). This narrowing appears to be due to fewer teachers of classes of LPA students agreeing with this statement in 2018 than in 2012 (33 vs. 51 percent).

Change Over Time:
Science Teaching Beliefs

Teachers Should Explain an Idea to Students Before Having them Consider Evidence that Relates to the Idea*



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, p < 0.05).

Figure 5.4

These items were combined into two composite variables: Reform-Oriented Teaching Beliefs and Traditional Teaching Beliefs. As can be seen in Table 5.21, teachers of classes of LPA students were less likely than teachers of classes of HPA students to hold reform-oriented teaching beliefs (mean scores of 84 vs. 88) and more likely to hold traditional teaching beliefs (mean scores of 61 vs. 57). The 2018 data are not significantly different from the 2012 data.

Table 5.21
Science Class Mean Scores for Teachers' Beliefs About Teaching and Learning Composites, by Prior Achievement

	MEAN SCORE		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
Reform-Oriented Teaching Beliefs*	88 (0.5)	87 (0.5)	84 (1.1)
(t) Traditional Teaching Beliefs*,a	57 (1.4)	55 (0.8)	61 (1.5)

(t) Trend composite

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, p < 0.05).

[a] This composite variable was not originally computed for the 2012 study. To allow for comparisons across time, it was computed for 2012 using the 2018 definition.

Teachers' Perceptions of Preparedness

Teachers were asked how well prepared they felt to teach each of a number of science topics at their assigned grade level. At the elementary level, few teachers, regardless of prior achievement level, felt prepared to teach any science topics (see Table 5.22). However, teachers of classes of LPA students were even less likely than teachers of classes of HPA students to feel well prepared to teach life science (18 vs. 47 percent). The 2018 data are not significantly different from the 2012 data.

Table 5.22
Elementary Classes in Which Teachers Considered Themselves Very Well Prepared to Teach Various Science Topics, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Life Science*	47 (7.1)	26 (1.9)	18 (4.9)
(t) Earth/space Science	32 (7.2)	21 (1.8)	17 (4.3)
(t) Physical Science	19 (5.4)	17 (2.1)	9 (3.2)
(t) Engineering	3 (2.5)	5 (2.1)	1 (0.8)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

At the secondary level, there are several differences in the percentages of classes taught by teachers considering themselves very well prepared to teach course topics by prior achievement level (see Table 5.23). In each case, teachers of classes of LPA students felt less prepared than teachers of classes of HPA students to teach science topics. The 2018 data are not significantly different from the 2012 data.

Table 5.23
Secondary Science Classes in Which Teachers[a] Considered Themselves Very Well Prepared to Teach Each of a Number of Topics, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
Earth/Space Science			
(t) Earth's features and physical processes	59 (6.4)	45 (2.5)	49 (5.8)
(t) The solar system and the universe	53 (5.6)	36 (2.5)	41 (5.6)
(t) Climate and weather*	45 (6.5)	36 (2.9)	28 (5.3)
Biology/Life Science			
(t) Structures and functions of organisms	68 (3.6)	64 (2.6)	61 (4.9)
(t) Cell biology*	69 (3.5)	62 (2.7)	55 (5.3)
(t) Ecology/ecosystems*	66 (3.8)	60 (2.4)	51 (4.4)
(t) Genetics*	70 (3.8)	56 (2.5)	50 (5.5)
(t) Evolution*	66 (3.5)	48 (2.6)	42 (4.7)
Chemistry			
(t) Atomic structure*	84 (3.0)	58 (2.9)	56 (7.5)
(t) States, classes, and properties of matter*	86 (2.7)	66 (2.5)	56 (5.8)
(t) Elements, compounds, and mixtures*	84 (2.9)	60 (2.7)	49 (5.4)
(t) The periodic table*	85 (2.7)	60 (3.2)	45 (6.2)
(t) Chemical bonding, equations, nomenclature, and reactions*	71 (3.6)	47 (3.0)	33 (4.6)
(t) Properties of solutions*	68 (3.8)	45 (2.6)	31 (4.0)
Physics			
(t) Forces and motion*	70 (3.9)	48 (2.9)	50 (6.6)
(t) Energy transfers, transformations, and conservation*	69 (4.0)	45 (2.4)	48 (6.7)
(t) Properties and behaviors of waves*	48 (3.6)	28 (2.3)	25 (4.8)
(t) Electricity and magnetism*	36 (3.4)	25 (2.9)	23 (3.8)
(t) Modern physics	17 (2.7)	9 (1.5)	12 (3.4)
(t) **Environmental and Resource Issues** (e.g., land and water use, energy resources and consumption, sources and impacts of pollution)	50 (5.9)	40 (3.4)	36 (5.8)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

[a] Each secondary science teacher was asked about one set of science topics based on the discipline of his/her randomly selected class.

As can be seen in Table 5.24, small percentages of science classes at the secondary level were taught by teachers who considered themselves very well prepared to teach various engineering topics. Further, teachers of classes of LPA students were less likely than teachers of classes of HPA students to feel well prepared to teach about optimizing design solutions and defining engineering problems (5 vs. 9 percent and 4 vs. 11 percent, respectively). This series of items was new to the 2018 NSSME+; thus, trend data are not available to report.

Table 5.24
Secondary Science Classes in Which Teachers Considered Themselves Very Well Prepared to Teach Each of a Number of Engineering Topics, by Prior Achievement

	PERCENT OF TEACHERS		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
Developing possible solutions	13 (1.6)	10 (0.9)	10 (3.0)
Optimizing design solutions*	9 (1.2)	8 (0.8)	5 (1.2)
Defining engineering problems*	11 (1.5)	9 (0.9)	4 (1.1)

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

The survey also asked teachers how well prepared they felt to use a number of student-centered pedagogies. As can be seen in Table 5.25, there are a number of differences by prior achievement level. For example, teachers of classes of LPA students felt less well prepared than their counterparts in classes of HPA students to use formative assessment to monitor student learning (34 vs. 57 percent), develop students' conceptual understanding (30 vs. 58 percent), or encourage students' interest in science and/or engineering (28 vs. 47 percent). For the one trend item, there is no significant difference over time.

Table 5.25
Science Classes in Which Teachers Considered Themselves Very Well Prepared for Each of a Number of Tasks, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
Use formative assessment to monitor student learning*	57 (2.7)	39 (1.6)	34 (3.3)
Develop students' conceptual understanding*	58 (2.7)	35 (1.3)	30 (3.0)
(t) Encourage students' interest in science and/or engineering*	47 (2.4)	35 (1.5)	28 (2.8)
Encourage participation of all students in science and/or engineering*	49 (2.2)	37 (1.5)	26 (2.4)
Develop students' abilities to do science (e.g., develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)*	47 (2.6)	28 (1.3)	25 (2.5)
Differentiate science instruction to meet the needs of diverse learners*	35 (2.2)	26 (1.5)	25 (2.6)
Provide science instruction that is based on students' ideas*	28 (2.2)	17 (1.4)	16 (2.4)
Incorporate students' cultural backgrounds into science instruction	18 (2.1)	14 (0.9)	15 (2.0)
Develop students' awareness of STEM careers*	25 (2.1)	14 (1.2)	12 (2.1)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

Table 5.26 shows the percentage of science classes taught by teachers who felt very well prepared for each of a number of tasks related to instruction within a particular unit in a designated class. The disparities between classes of LPA students and classes of HPA students are numerous, with teachers of classes of LPA students perceiving themselves as less well prepared than teachers of classes of HPA students to implement each of the five tasks. For example, 39 percent of teachers of classes of LPA students felt very well prepared to assess student understanding at the conclusion of the unit compared to 63 percent of teachers of classes of HPA students. Looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 5.26
Science Classes in Which Teachers Felt Very Well Prepared for Various Tasks in the Most Recent Unit, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Assess student understanding at the conclusion of this unit*	63 (2.6)	42 (1.3)	39 (3.2)
(t) Monitor student understanding during this unit*	59 (2.2)	40 (1.4)	37 (3.5)
(t) Implement the instructional materials to be used during this unit*	56 (2.2)	38 (1.4)	35 (3.2)
(t) Anticipate difficulties that students may have with particular science ideas and procedures in this unit*	49 (2.4)	29 (1.4)	29 (2.8)
(t) Find out what students thought or already knew about the key science ideas*	47 (2.7)	34 (1.4)	26 (2.6)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

The preparedness items were used to create four composite variables: Perceptions of Science Content Preparedness, Perceptions of Engineering Content Preparedness, Perceptions of Pedagogical Preparedness, and Preparedness to Implement Instruction in a Particular Unit. As can be seen in Table 5.27, classes of LPA students were less likely than classes of HPA students to be taught by teachers who had strong feelings of science content preparedness (mean scores of 61 vs. 81), pedagogical preparedness (mean scores of 60 vs. 72), or preparedness to implement instruction in a particular unit (mean scores of 69 vs. 82).

Table 5.27
Science Class Mean Scores for Teachers' Perceptions of Preparedness Composites, by Prior Achievement

	MEAN SCORE		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Perceptions of Content Preparedness*,[a]	81 (1.3)	62 (0.8)	61 (1.7)
Perceptions of Preparedness to Teach Engineering	38 (1.7)	38 (1.0)	33 (2.6)
Perceptions of Pedagogical Preparedness*	72 (1.1)	63 (0.7)	60 (1.3)
(t) Perceptions of Preparedness to Implement Instruction in Particular Unit*	82 (0.9)	73 (0.6)	69 (1.4)

(t) Trend composite

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed for 2018 using the 2012 definition. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

From 2012 to 2018, the gap between classes of LPA students and classes of HPA students for the Perceptions of Preparedness to Implement Instruction in Particular Unit Composite has changed (see Figure 5.5). This change appears to be due to a moderate decrease over time for classes of LPA students (from 75 to 69) and only a slight decrease for classes of HPA students (from 84 to 82).

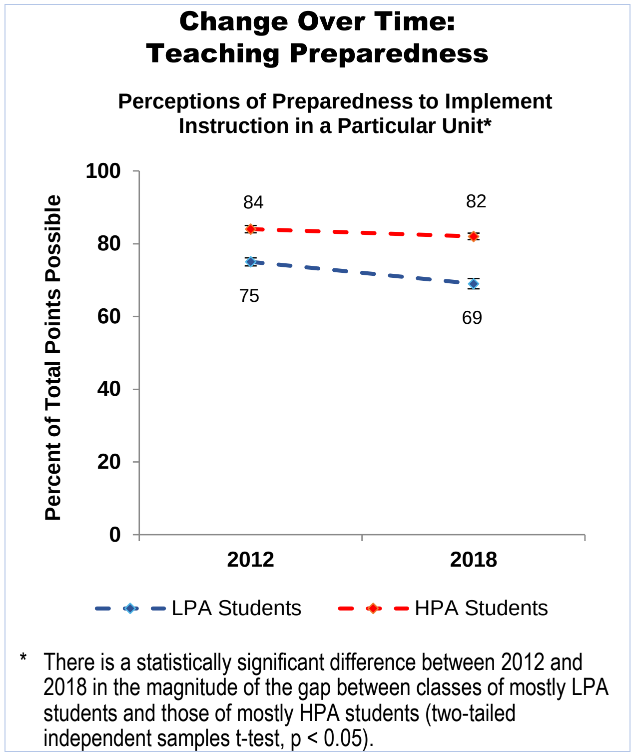


Figure 5.5

Teacher Professional Development

In 2018, large percentages of classes, regardless of prior achievement level, were taught by teachers who participated in science-focused professional development in the previous three years (see Table 5.28). However, teachers of classes of LPA students were less likely than teachers of classes of HPA students to have had professional development in the previous three years (70 vs. 82 percent). In addition, teachers of classes of LPA students were less likely than teachers of classes of HPA students to have had more than 35 hours of professional development in the previous three years (15 vs. 36 percent).

Table 5.28
Professional Development Experiences of Teachers of Science Classes, by Prior Achievement

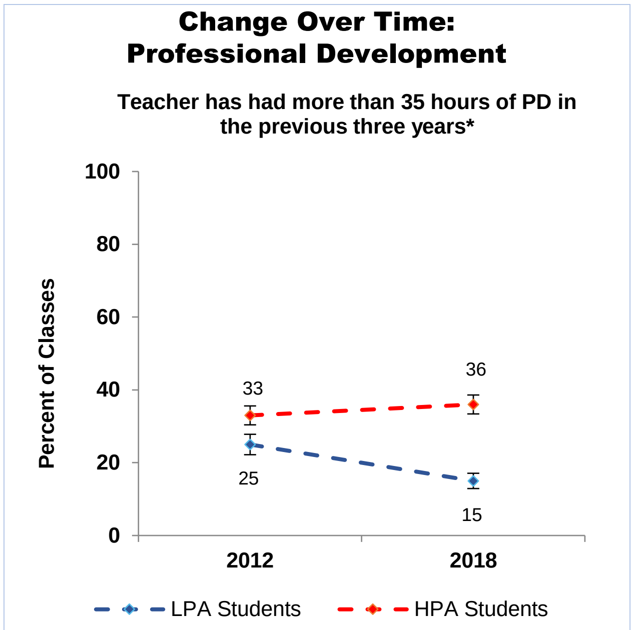
	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Teacher has had professional development in the previous three years*	82 (2.0)	69 (1.5)	70 (3.3)
(t) Teacher has had more than 35 hours of professional development in the previous three years*	36 (2.6)	15 (0.8)	15 (2.1)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

As can be seen in Figure 5.6, from 2012 to 2018, the gap between classes of LPA students and classes of HPA students taught by teachers who had more than 35 hours of professional development has widened. This widening appears to be due to a decrease in the percentage of classes of LPA students taught by a teacher with substantial professional development (from 25 to

15 percent) and an increase in the percentage of classes of HPA students taught by a teacher with substantial professional development (from 33 to 36 percent).



* There is a statistically significant difference between 2012 and 2018 in the magnitude of the gap between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

Figure 5.6

As described in previous chapters, there is consensus that professional development experiences should include a number of elements, including opportunities to work with colleagues, engage in investigations, examine student work, and rehearse instructional practices.[33] Therefore, teachers who had participated in professional development in the previous three years were asked a series of questions about the nature of those experiences.

As can be seen in Table 5.29, teachers of classes of LPA and HPA students who participated in professional development had similar experiences. For example, roughly 45–60 percent of classes were taught by teachers who worked closely with other teachers from their schools or with other teachers who taught the same grade and/or subject, whether or not they were from their schools. Additionally, more than one-third of classes were taught by teachers who had opportunities to apply what they learned to their classroom and then come back and talk about it. However,

[33] Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*(3), 181–199.

Elmore, R. F. (2002). *Bridging the gap between standards and achievement: The imperative for professional development in education.* Albert Shanker Institute.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915–945.

teachers of classes of LPA students were less likely than teachers of HPA students to have had a professional development experience that included opportunities to experience lessons, as their students would, from the textbook/modules they use in their classroom (33 vs. 47 percent) or opportunities to engage in science investigations/engineering design challenges (31 vs. 46 percent). The 2018 data are not significantly different from the 2012 data.

Table 5.29
Science Classes in Which Teachers' Professional Development in the Previous Three Years Had Each of a Number of Characteristics to a Substantial Extent,[a] by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Worked closely with other teachers from their school	57 (3.4)	59 (2.0)	49 (4.7)
(t) Worked closely with other teachers who taught the same grade and/or subject whether or not they were from their school	57 (3.8)	51 (2.0)	45 (4.5)
(t) Had opportunities to apply what they learned to their classroom and then come back and talk about it as part of the professional development	44 (3.5)	35 (1.9)	36 (4.0)
Had opportunities to experience lessons, as their students would, from the textbook/modules they use in their classroom*	47 (3.5)	44 (2.1)	33 (3.6)
(t) Had opportunities to engage in science investigations/engineering design challenges*	46 (3.6)	44 (2.0)	31 (3.9)
(t) Had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction)	38 (3.1)	35 (1.9)	30 (3.6)
Had opportunities to rehearse instructional practices during the professional development (i.e., try out, receive feedback, and reflect on those practices)	34 (3.5)	27 (1.7)	27 (3.3)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes high school science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent."

As can be seen in Table 5.30, for teachers who participated in professional development, the emphases of these experiences were similar in many ways, regardless of the prior achievement level of the class. For example, teachers in roughly 40–50 percent of classes had professional development opportunities that heavily emphasized monitoring student understanding during science instruction, differentiating science instruction to meet the needs of diverse learners, and deepening their own science content knowledge. However, teachers of classes of LPA students were less likely than teachers of classes of HPA students to have attended a professional development session that heavily emphasized deepening their understanding of how science is done (35 vs. 53 percent), learning how to provide science instruction that integrates engineering, mathematics, and/or computer science (33 vs. 45 percent), or deepening their understanding of how engineering is done (16 vs. 27 percent). When looking at trends over time, the 2018 data are not significantly different from the 2012 data.

Table 5.30
Science Classes Taught by Teachers Whose Professional Development in the Previous Three Years Gave Heavy Emphasis[a] to Various Areas, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Monitoring student understanding during science instruction	52 (3.8)	44 (2.3)	43 (4.4)
Differentiating science instruction to meet the needs of diverse learners	49 (3.4)	42 (2.0)	40 (4.0)
(t) Deepening their own science content knowledge	47 (3.8)	46 (1.9)	38 (4.3)
Deepening their understanding of how science is done (e.g., developing scientific questions, developing and using models, engaging in argumentation)*	53 (3.6)	51 (2.1)	35 (4.3)
(t) Finding out what students think or already know prior to instruction on a topic	42 (3.1)	37 (2.2)	34 (4.3)
Learning how to provide science instruction that integrates engineering, mathematics, and/or computer science*	45 (4.0)	37 (2.2)	33 (4.4)
(t) Learning about difficulties that students may have with particular science ideas	35 (3.5)	33 (2.1)	32 (4.5)
Incorporating students' cultural backgrounds into science instruction	22 (2.6)	22 (1.8)	30 (3.7)
(t) Implementing the science textbook/modules to be used in their classroom	35 (3.4)	31 (1.9)	28 (4.4)
Deepening their understanding of how engineering is done (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)*	27 (2.8)	27 (1.8)	16 (2.8)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes high school science teachers indicating 4 or 5 on a five-point scale ranging from 1 "not at all" to 5 "to a great extent."

Responses to a subset of these items were combined into two composite variables called Extent Professional Development Aligns with Elements of Effective Professional Development and Extent Professional Development Supports Student-Centered Instruction. As can be seen in Table 5.31, class mean scores of approximately 50 indicate that teachers' professional development opportunities were only somewhat aligned with elements of effective professional development and somewhat supportive of student-centered instruction. In addition, teachers of classes of LPA students were less likely than teachers of classes of HPA students to experience professional development that was aligned with either of these areas. Looking over time, the 2018 composite mean scores are not significantly different from the 2012 scores.

Table 5.31
Science Class Mean Scores for Teachers' Professional Development Composites, by Prior Achievement Level

	MEAN SCORE		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Extent Professional Development Aligns With Elements of Effective Professional Development*,[a]	57 (1.3)	52 (0.8)	48 (1.6)
Extent Professional Development Supports Student-Centered Instruction*	54 (1.4)	51 (1.0)	49 (1.8)

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed using only the items in common at both time points. Because there is no significant difference between the two time points on this composite, the data in this table are based on the original 2018 composite definition.

Summary

Overall, there are similarities and differences between classes of LPA and HPA students in terms of teachers' backgrounds and experiences. Most elementary and middle grades classes, regardless of prior achievement level, were taught by teachers who had completed the majority of NSTA recommended courses. However, at the secondary level, classes of LPA students were less likely than classes of HPA students to be taught by teachers with a degree in science or science education or 3 or more advanced courses in the subject. Further, across grade levels, classes of LPA students were more likely than classes of HPA students to be taught by inexperienced teachers.

Teachers of classes of LPA students were less likely than teachers of classes of HPA students to hold reform-oriented teaching beliefs and more likely to hold traditional teaching beliefs. Additionally, classes of LPA students were somewhat less likely than classes of HPA students to be taught by teachers who had strong feelings of content preparedness and preparedness to monitor and address student thinking during instruction.

A large majority of classes across prior achievement levels were taught by teachers who participated in science-focused professional development in the previous three years, and that professional development had similar characteristics and emphases regardless of prior achievement level. However, teachers of classes of LPA students were somewhat less likely than teachers of classes of HPA students to experience lessons as their students would and engage in science investigations/engineering design challenges during professional development. In addition, their professional development experiences were less likely to heavily emphasize deepening their understanding of how science is done or learning how to provide science instruction that integrates engineering, mathematics, and/or computer science.

Since 2012, the distribution of well-prepared teachers between classes with low and high levels of prior achievement has remained largely consistent. However, there were some changes. For example, the gap between classes of LPA and HPA students taught by teachers from historically underrepresented races/ethnicities in STEM has narrowed, likely due to a slight decrease of these teachers in classes of LPA students and a slight increase in classes of HPA students from 2012 to 2018. Additionally, the gap between classes of LPA and HPA students taught by high school teachers with three or more advanced courses in the subject has widened, a change that disadvantages classes of LPA students. Further, the gap between classes of LPA and HPA students taught by teachers who have had more than 35 hours of PD has become more pronounced over time, disadvantaging classes of LPA students.

Supportive Context for Learning

The 2018 NSSME+ collected information about factors that could promote and inhibit effective science instruction in the school, including school policies and stakeholder support. This section presents these data, highlighting the similarities and differences between classes of LPA students and classes of HPA students.

Factors Affecting Student Opportunity to Learn

Table 5.32 displays the percentages of classes taught by teachers who rated various factors as promoters of effective instruction. Teachers of classes with low levels of prior achievement were less likely than teachers of classes with high levels of prior achievement to rate a number of factors as promotors of effective science instruction. For example, teachers of classes with low levels of prior achievement were less likely than teachers of classes with high levels of prior achievement to rate principal support (55 vs. 69 percent); students' motivation, interest, and effort in science (52 vs. 77 percent); and the amount of time to plan individually and with colleagues (52 vs. 73 percent) as factors promoting effective science instruction. The 2018 data are not significantly different from the 2012 data.

Table 5.32
Factors Promoting[a] Effective Instruction in Science Classes, by Prior Achievement

	PERCENT OF CLASSES		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Principal support*	69 (3.1)	68 (1.8)	55 (4.1)
(t) Current state standards	53 (4.1)	66 (1.7)	55 (3.8)
(t) Students' motivation, interest, and effort in science*	77 (2.8)	68 (1.6)	52 (4.1)
(t) Amount of time for you to plan, individually and with colleagues*	73 (2.9)	62 (1.8)	52 (4.5)
Amount of instructional time devoted to science[b]	61 (11.2)	48 (2.9)	48 (6.5)
Students' prior knowledge and skills*	69 (3.2)	59 (1.5)	44 (4.2)
(t) Pacing guides*	53 (3.4)	55 (2.1)	42 (3.8)
(t) Amount of time available for your professional development*	58 (3.4)	48 (2.0)	37 (3.8)
(t) College entrance requirements*[,c]	60 (3.2)	51 (3.1)	36 (6.4)
(t) Parent/guardian expectations and involvement*	54 (3.6)	38 (1.4)	33 (3.7)
(t) Textbook/module selection policies	36 (3.5)	35 (2.0)	33 (4.2)
(t) Teacher evaluation policies	40 (2.9)	42 (2.0)	31 (3.8)
(t) State/district/diocese testing/accountability policies[d]	33 (3.3)	35 (1.9)	28 (3.2)

(t) Trend item

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes science teachers indicating 4 or 5 on a five-point scale ranging from 1 "inhibits effective instruction" to 5 "promotes effective instruction."

[b] This item was presented only to elementary school teachers.

[c] This item was presented only to high school teachers.

[d] This item was presented only to teachers in public and catholic schools.

Three composites were created from these items: (1) Extent to Which School Support Promotes Effective Instruction; (2) Extent to Which the Policy Environment Promotes Effective Instruction; and (3) Extent to Which Stakeholders Promote Effective Instruction. As can be seen in Table 5.33, each of these factors appears to have a moderate influence on effective instruction across prior achievement levels. However, the mean scores on all three composites were significantly lower for classes of LPA students than classes of HPA students. Looking at trends, the 2018 data are not significantly different from the 2012 data.

Table 5.33
Science Class Mean Scores for Factors Affecting Instruction Composites, by Prior Achievement

	MEAN SCORE		
	MOSTLY HIGH	AVERAGE/MIXED	MOSTLY LOW
(t) Extent to Which School Support Promotes Effective Instruction*	72 (1.9)	65 (1.2)	58 (3.1)
(t) Extent to Which the Policy Environment Promotes Effective Instruction*,[a]	63 (1.2)	63 (0.8)	58 (1.4)
Extent to Which Stakeholders Promote Effective Instruction*	73 (1.3)	66 (0.9)	52 (2.9)

(t) Trend composite

* There is a statistically significant difference between classes of mostly LPA students and those of mostly HPA students (two-tailed independent samples t-test, $p < 0.05$).

[a] This composite variable was computed differently in 2012 and 2018. To allow for comparisons across time, it was recomputed for 2012 using the 2018 definition.

Summary

Overall, teachers of science classes viewed the climate for science instruction as generally supportive in terms of school support, policies, and stakeholders, regardless of prior achievement level of the class. Current state standards were seen by a majority of science classes as one factor promoting effective instruction. However, there were also significant differences between classes of LPA and HPA students on a number of items, with teachers of classes of LPA students consistently less likely to view these factors (e.g., principal support; student motivation, interest, and effort in science; and the amount of time to plan, individually and with colleagues) as promoting effective instruction.

Quartile Cut Points

Quartile cut points are the values that separate one quartile from another such that roughly 25 percent of schools or classes are represented in each quartile. The lowest quartile includes the group that has values below the Quartile 1/Quartile 2 cut point, and the highest quartile includes the group with values above the Quartile 3/Quartile 4 cut point.

Each school was classified into 1 of 4 categories based on the proportion of students eligible for free/reduced-price lunch (FRL). Defining common categories across grades K–12 would have been misleading, as students tend to select out of the FRL program as they advance in grade due to perceived social stigma. Therefore, the categories were defined as quartiles within groups of schools serving the same grades—e.g., schools with grades K–5, schools with grades 6–8 (see Table A-1).

Table A-1
Cut Points for Percentage of Students in the School Eligible for FRL

		PERCENT FRL USED AS CUTPOINT		
	PERCENT OF SCHOOLS	QUARTILE 1/QUARTILE 2	QUARTILE 2/QUARTILE 3	QUARTILE 3/QUARTILE 4
K–5 Schools	38 (1.6)	33.8	53.6	82.4
6–8 Schools	12 (0.4)	37.6	55.9	80.0
9–12 Schools	15 (0.8)	18.8	40.3	18.8
K–8 Schools	25 (1.7)	17.5	46.2	78.8
6–12 Schools	4 (0.5)	27.0	48.0	66.3
9–12 Schools	6 (0.9)	4.2	34.3	82.5

Each randomly selected class was classified into 1 of 4 categories based on the proportion of students in the class identified as being from race/ethnicity groups historically underrepresented in STEM (i.e., American Indian or Alaskan Native, Black or African American, Hispanic or Latino, Native Hawaiian or Other Pacific Islander, multi-racial). As this proportion is similar in schools regardless of grades served, the categories were defined as quartiles across all classes (see Table A-2).

Table A-2
Cut Points for Percentage of Students in the Class From Race/Ethnicity Groups Historically Underrepresented in STEM

	PERCENT HUS USED AS CUTPOINT
Quartile 1/Quartile 2	9.1
Quartile 2/Quartile 3	26.9
Quartile 3/Quartile 4	66.7

Trend Item Wording Differences

The wording of some survey items changed between the 2012 and 2018 iterations of the study. Items with slightly different wording were treated as trend. These items, separated by instrument, are shown in the tables below, along with references to tables in this report that the items appear in.[34]

Table B-1
School Coordinator Questionnaire Trend Item Differences

2018 ITEM #	2012 ITEM #	FRL TABLE #	COMMUNITY TYPE TABLE #
scq08a	scq08	2.15	3.15
scq08b	scq10a	2.15	3.15

Table B-2
Science Program Questionnaire Trend Item Differences

2018 ITEM #	2012 ITEM #	FRL TABLE #	COMMUNITY TYPE TABLE #
spq18	spq39	2.34	3.34
spq20	spq41	2.34	3.34
spq33	spq54	2.34	3.34
spq19a	spq40a	2.35	3.35
spq19f	spq40c	2.35	3.35
spq29a	spq50a	2.36	3.36
spq29f	spq50c	2.36	3.36
spq02a	spq02a	2.40	3.40
spq02b	spq02b	2.40	3.40
spq03d	spq03e	2.41	3.41
spq03e	spq03f	2.41	3.41
spq16b	spq32b	2.44	3.44
spq16d	spq32e	2.44	3.44
spq17c	spq33c	2.45	3.45
spq17e	spq33d	2.45	3.45
spq17k	spq33i	2.45	3.45
spq17p	spq33p	2.45	3.45

[34] The 2012 instruments are available at: http://horizon-research.com/NSSME/2012-nssme/instruments, and the 2018 instruments are available at: http://horizon-research.com/NSSME/2018-nssme/instruments.

Table B-3
Science Teacher Questionnaire Trend Item Differences

2018 ITEM #	2012 ITEM #	FRL TABLE #	COMMUNITY TYPE TABLE #	HUS TABLE #	PRIOR ACHIEVEMENT TABLE #
stq44b	stq44b	2.4	3.4	4.4	5.4
stq45f	stq45d	2.6	3.6	4.6	5.6
stq45g	stq45e	2.6	3.6	4.6	5.6
stq46d	stq46d	2.8	3.8	4.8	5.8
stq46f	stq46f	2.8	3.8	4.8	5.8
stq51	stq51	2.11	3.11	4.11	5.11
stq36e	stq37e	2.26	3.26	4.24	5.24
stq33a	stq32a	2.31	3.31	4.29	5.29
stq33e	stq32c	2.31	3.31	4.29	5.29
stq33f	stq32e	2.31	3.31	4.29	5.29
stq33g	stq32f	2.31	3.31	4.29	5.29
stq34e	stq34b	2.32	3.32	4.30	5.30
stq34f	stq34c	2.32	3.32	4.30	5.30
stq60b	stq63d	2.47	3.47	4.32	5.32
stq60i	stq63l	2.47	3.47	4.32	5.32
stq60k	stq63n	2.47	3.47	4.32	5.32
stq60l	stq63o	2.47	3.47	4.32	5.32

Alternate Composite Definitions Used in Trend Analyses

Some composite variables were computed differently for this report than in an individual year's report to allow for comparisons between the two time points. When there is a significant difference between the two time points, the data shown in this report are based on the recomputed composite definition. The definitions for the recomputed composites are shown in the following tables.

Table C-1
Extent Professional Development Aligns With Elements of Effective Professional Development: HUS

	SCIENCE TEACHER QUESTIONNAIRE ITEM†
I had opportunities to engage in science investigations/engineering design challenges.	stq33a
I had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction).	stq33c
I had opportunities to apply what I learned to my classroom and then come back and talk about it as part of the professional development.	stq33e
I worked closely with other teachers from my school.	stq33f
I worked closely with other teachers who taught the same grade and/or subject whether or not they were from my school.	stq33g
Number of Items in Composite	**5**
Reliability – Cronbach's Coefficient Alpha	**0.77**
Confirmatory Factor Analysis Fit Index – SRMR	**0.05**

† These items were presented only to teachers who participated in science/engineering-focused professional development in the previous three years.