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2018 NSSME+: Status of High School Chemistry

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Disclaimer

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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. 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 iteration of the study included an emphasis on computer science, particularly at the high school level, which is increasingly prominent in discussions about K–12 STEM education and college and career readiness. The 2018 NSSME+ (the plus symbol reflecting the additional focus) 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. The research questions addressed by the study are:

1. To what extent do computer science, mathematics, and science instruction reflect what is known about effective teaching?
2. What are the characteristics of the computer science/mathematics/science teaching force in terms of race, gender, age, content background, beliefs about teaching and learning, and perceptions of preparedness?
3. What are the most commonly used textbooks/programs, and how are they used?
4. What influences teachers' decisions about content and pedagogy?
5. What formal and informal opportunities do computer science/mathematics/science teachers have for ongoing development of their knowledge and skills?
6. How are resources for computer science/mathematics/science education, including well-prepared teachers and course offerings, distributed among schools in different types of communities and different socioeconomic levels?

The 2018 NSSME+ is based on a national probability sample of schools and computer science, mathematics, and science teachers in grades K–12 in the 50 states and the District of Columbia. The sample was designed to yield national estimates of course offerings and enrollment, teacher background preparation, textbook usage, instructional techniques, and availability and use of facilities and equipment. Every eligible school and teacher in the target population had a known, positive probability of being sampled. A total of 7,600 computer science, mathematics, and science teachers in 1,273 schools across the United States participated in this study, a response rate of 78 percent.

Because biology is by far the most common science course at the high school level, selecting a random sample of science teachers would result in a much larger number of biology teachers than chemistry or physics teachers. In order to ensure that the sample would include a sufficient number of chemistry and physics teachers for separate analysis, information on teaching assignments was used to create a separate domain for these teachers, and sampling rates were adjusted by domain.

This report describes the status of high school (grades 9–12) chemistry instruction based on the responses of 763 chemistry teachers.[1] For comparison purposes, many of the tables include data from all 1,740 respondents who teach high school science, regardless of the subject area, and/or data for biology and physics teachers.[2] Each teacher responding to the survey was asked to provide detailed information about a randomly selected class. Science teachers who were assigned to teach both chemistry and other science classes may have been asked about any of those classes. Accordingly, the number of chemistry classes included in the analyses reported below (556) is smaller than the number of responding teachers of chemistry. Generally, the larger standard errors for class-level data are a reflection of the reduced sample size.

Detail on the survey sample design, data collection and analysis procedures, and creation of composite variables[3] are included in the *Report of the 2018 NSSME+*.[4] The standard errors for the estimates presented in this report are included in parentheses in the tables. The narrative sections of the report generally point out only those differences that are substantial as well as statistically significant at the 0.05 level.[5]

This status report of high school chemistry teaching is organized into major topical areas:

- Characteristics of the chemistry teaching force;
- Professional development of chemistry teachers;
- Chemistry courses offered;
- Chemistry instruction, in terms of time spent, objectives, and activities;
- Resources available for chemistry instruction; and
- Factors affecting chemistry instruction.

High School Chemistry Teachers' Backgrounds and Beliefs

A well-prepared teaching force is essential for an effective education system. This section provides data about the nation's high school chemistry teachers, including their course backgrounds, beliefs about teaching and learning, and perceptions of preparedness.

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[1] A chemistry teacher is defined as someone who teaches at least one class of non-college prep, 1st year college prep, or 2nd year advanced chemistry.

[2] Detailed information for high school physics and biology teachers can be found in *2018 NSSME+: Status of High School Biology* (Wingard, 2019) and *2018 NSSME+: Status of High School Physics* (Banilower, 2019).

[3] Factor analysis was used to create several composite variables related to key constructs measured on the questionnaires. Composite variables, which are more reliable than individual survey items, were computed to have a minimum possible value of 0 and a maximum possible value of 100.

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

[5] The False Discovery Rate was used to control the Type I error rate when comparing multiple groups on the same outcome. Benjamini, Y. and Hochberg, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to multiple testing. Journal of the Royal Statistical Society: Series B, 57(1), 289–300.

Teacher Characteristics

As in the other sciences, over half of chemistry teachers are female, and the overwhelming majority are white (see Table 1). Judging by the age of chemistry teachers, it appears that just over a quarter may be nearing retirement in the next 10 years. Interestingly, about 40 percent of chemistry teachers have had full-time job experience in a science- or engineering-related field prior to teaching, which is similar to other high school science teachers.

Table 1
Characteristics of the High School Science Teaching Force

	PERCENT OF TEACHERS	
	ALL SCIENCES	CHEMISTRY
Sex		
Female	57 (1.9)	58 (2.6)
Male	43 (1.9)	42 (2.6)
Other	0 (0.0)	0 (0.1)
Hispanic or Latino		
Yes	6 (0.8)	8 (1.4)
No	94 (0.8)	92 (1.4)
Race		
White	91 (1.2)	90 (1.3)
Asian	5 (0.9)	6 (0.9)
Black or African American	5 (0.9)	6 (1.0)
American Indian or Alaska Native	2 (0.5)	1 (0.5)
Native Hawaiian or Other Pacific Islander	0 (0.1)	1 (0.3)
Age		
≤ 30	14 (0.9)	16 (2.0)
31–40	31 (1.5)	26 (2.0)
41–50	28 (1.3)	29 (2.4)
51–60	20 (1.1)	21 (1.6)
61+	8 (0.9)	7 (1.0)
Experience Teaching Science at the K–12 Level		
0–2 years	15 (1.1)	14 (1.8)
3–5 years	13 (0.9)	11 (1.6)
6–10 years	17 (1.4)	19 (2.6)
11–20 years	35 (1.9)	33 (2.2)
≥ 21 years	20 (1.2)	23 (2.1)
Full-Time Job in Science Prior to Teaching		
Yes	36 (2.1)	39 (2.9)
No	64 (2.1)	61 (2.9)

The majority of chemistry teachers have one or two preparations—different subjects or levels (e.g., intro/1st year chemistry, 2nd year physics)—though nearly 40 percent have three or more preparations (see Table 2). These data are similar to those for biology and physics teachers.

Table 2
Number of Science Preparations

	PERCENT OF TEACHERS			
	ALL SCIENCES	BIOLOGY	CHEMISTRY	PHYSICS
1	28 (1.6)	21 (2.2)	16 (1.4)	15 (2.5)
2	48 (1.8)	46 (2.6)	46 (2.1)	46 (3.3)
3	17 (1.3)	20 (2.6)	23 (2.0)	26 (2.4)
4 or more	7 (0.9)	12 (1.8)	15 (2.5)	13 (2.8)

The vast majority of chemistry teachers have had formal preparation for teaching leading to a teaching credential (see Table 3). Two-thirds received their teaching credential as part of their undergraduate program or a non-master's post-baccalaureate program.

Table 3
High School Science Teachers' Paths to Certification

	PERCENT OF TEACHERS			
	ALL SCIENCES	BIOLOGY	CHEMISTRY	PHYSICS
An undergraduate program leading to a bachelor's degree and a teaching credential	40 (1.9)	39 (2.9)	40 (2.8)	42 (4.8)
A master's program that also awarded a teaching credential	28 (2.2)	30 (4.3)	26 (2.3)	25 (3.6)
A post-baccalaureate credentialing program (no master's degree awarded)	25 (1.7)	23 (2.7)	24 (2.4)	23 (3.4)
Has not earned a teaching credential	7 (1.0)	7 (1.4)	9 (2.3)	10 (2.3)

As can be seen in Table 4, 85 percent of chemistry teachers are certified in their subject area, which is similar to biology teachers. In contrast, chemistry teachers are more likely to be certified in their subject area than Earth/space science, ecology/environmental science, and physics teachers.

Table 4
High School Science Teachers' Certified in Subjects They Teach

	PERCENT OF TEACHERS†
Biology	88 (1.9)
Chemistry	85 (2.8)
Physics	75 (4.0)
Earth/Space Science	70 (5.5)
Ecology/Environmental Science	43 (5.9)

† Teachers assigned to teach classes in more than one subject area are included in each subject area.

Content Preparedness

More than 8 in 10 chemistry teachers have a college degree in science or engineering, a slightly higher percentage than high school science teachers in general; roughly half have a degree in science education, which is similar to all high school science teachers (see Table 5).

Table 5
High School Science Teacher Degrees

	PERCENT OF TEACHERS	
	ALL SCIENCES	CHEMISTRY
Science/Engineering	79 (1.4)	84 (1.8)
Science Education	57 (2.1)	55 (2.9)
Science/Engineering or Science Education	91 (1.1)	92 (1.9)

The majority of chemistry teachers do not have a degree in chemistry, but they are considerably more likely than physics teachers and considerably less likely than biology teachers to have a degree in their field (see Table 6). Forty-two percent have a degree in their subject, and another 28 percent do not have a degree but have three or more courses beyond the introductory level in chemistry.

Table 6
High School Science Teachers With Varying Levels of Background in Subject

	PERCENT OF TEACHERS		
	BIOLOGY	CHEMISTRY	PHYSICS
Degree in field	63 (2.5)	42 (2.7)	24 (2.6)
No degree in field, but 3+ courses beyond introductory	25 (2.6)	28 (2.2)	27 (3.1)
No degree in field, but 1–2 courses beyond introductory	6 (1.1)	20 (2.1)	15 (2.6)
No degree in field or courses beyond introductory	5 (1.4)	9 (1.9)	30 (3.7)
No coursework in field	1 (0.5)	1 (0.6)	4 (1.2)

Table 7 shows various college courses completed by chemistry teachers. Ninety-nine percent of chemistry teachers have taken an introductory chemistry course. Eighty-six percent have taken at least one course in organic chemistry, 64 percent a course in inorganic chemistry, and 52 percent a course in physical chemistry. Almost half of chemistry teachers have taken a chemistry teaching methods course.

Table 7
High School Chemistry Teachers Completing Various Chemistry College Courses

	PERCENT OF CHEMISTRY TEACHERS
Introductory Chemistry	**99 (0.6)**
One or More Chemistry Courses Beyond the Introductory Level	**90 (2.0)**
Organic Chemistry	86 (2.2)
Inorganic Chemistry	64 (3.0)
Biochemistry	60 (2.8)
Analytic Chemistry	55 (2.6)
Physical Chemistry	52 (2.9)
Quantum Chemistry	16 (1.6)
Other chemistry beyond the general/introductory level	31 (2.8)
Chemistry Teaching Methods Course	**45 (2.8)**

The survey also asked chemistry teachers to rate how well prepared they feel to teach each of a number of fundamental topics in chemistry. A large majority of chemistry teachers feel very well prepared to teach about atomic structure; elements, compounds, and mixtures; and the periodic table, among others (see Table 8). Few chemistry teachers feel less than fairly well prepared in any of these areas.

Table 8
High School Chemistry Teachers' Perceptions of Their Preparedness to Teach Each of a Number of Topics

	PERCENT OF CHEMISTRY TEACHERS			
	NOT ADEQUATELY PREPARED	SOMEWHAT PREPARED	FAIRLY WELL PREPARED	VERY WELL PREPARED
Atomic structure	0 ---†	1 (0.7)	8 (1.5)	91 (1.7)
Elements, compounds, and mixtures	0 ---†	1 (0.7)	8 (1.7)	91 (1.8)
The periodic table	0 ---†	1 (0.7)	8 (1.8)	91 (1.9)
States, classes, and properties of matter	0 ---†	1 (0.7)	9 (1.6)	90 (1.9)
Chemical bonding, equations, nomenclature, and reactions	1 (0.7)	1 (0.9)	9 (1.6)	89 (1.8)
Properties of solutions	1 (0.7)	4 (1.4)	16 (1.9)	79 (2.4)

† No high school chemistry teachers in the sample selected this response option. Thus, it is not possible to calculate the standard error of this estimate.

Data from items asking teachers how well prepared they feel to teach the content of a randomly selected science course in their schedule were combined into a composite variable called Perceptions of Preparedness to Teach Science Content. As can be seen in Table 9, chemistry teachers feel better prepared than teachers of biology and physics feel to teach their specific discipline.

Table 9
Mean Scores for High School Science Teachers' Perceptions of Content Preparedness Composite†

	MEAN SCORE
All sciences	88 (0.6)
Biology	85 (0.9)
Chemistry	91 (0.9)
Physics	83 (1.3)

† Composite definition is based on the content of each teacher's randomly selected class.

The survey also asked teachers how well prepared they feel to incorporate engineering into their science instruction. Fewer than 40 percent of chemistry teachers feel at least fairly well prepared to teach students about defining engineering problems, developing possible solutions, or optimizing solutions (see Table 10). Fewer than 1 in 10 feel very well prepared in these areas.

Table 10
High School Chemistry Teachers' Perceptions of Their Preparedness to Teach Engineering

	PERCENT OF CHEMISTRY TEACHERS			
	NOT ADEQUATELY PREPARED	SOMEWHAT PREPARED	FAIRLY WELL PREPARED	VERY WELL PREPARED
Developing possible solutions	34 (2.8)	31 (2.3)	27 (2.6)	8 (1.2)
Defining engineering problems	37 (2.5)	35 (2.1)	20 (1.9)	8 (1.3)
Optimizing a design solution	40 (2.8)	35 (2.2)	18 (2.1)	6 (1.1)

These items were combined into a composite variable titled Perceptions of Preparedness to Teach Engineering. As can be seen in Table 11, chemistry teachers feel better prepared to teach engineering than high school biology teachers and considerably less well prepared than high school physics teachers.

Table 11
Mean Scores for High School Science Teachers' Perceptions of Preparedness to Teach Engineering Composite

	MEAN SCORE
All sciences	33 (1.0)
Biology	28 (1.4)
Chemistry	33 (1.6)
Physics	46 (2.4)

Pedagogical Preparedness

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 feel to use various student-centered pedagogies. Second, they were asked how well prepared they feel to monitor and address student understanding, focusing on a specific unit in the randomly selected class.

As can be seen in Table 12, the majority of chemistry teachers feel very well prepared to develop students' conceptual understanding and use formative assessment to monitor student learning. However, only a third to half feel very well prepared to encourage students' interest in science and/or engineering, to encourage the participation of all students in science/engineering, and to differentiate science instruction to meet the needs of diverse learners. Only about 1 in 5 feel very well prepared to incorporate students' cultural backgrounds into science instruction. In all of these aspects, chemistry teachers are similar to high school science teachers more broadly.

Table 12
High School Science Teachers Considering Themselves Very Well Prepared for Each of a Number of Tasks

	PERCENT OF TEACHERS	
	ALL SCIENCES	CHEMISTRY
Develop students' conceptual understanding	58 (1.5)	61 (2.5)
Use formative assessment to monitor student learning	52 (1.6)	57 (2.3)
Develop students' abilities to do science (e.g., develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)	46 (1.6)	49 (2.4)
Encourage students' interest in science and/or engineering	44 (1.6)	48 (2.3)
Encourage participation of all students in science and/or engineering	43 (1.6)	46 (2.2)
Differentiate science instruction to meet the needs of diverse learners	35 (1.5)	35 (2.1)
Provide science instruction that is based on students' ideas	25 (1.4)	26 (2.1)
Develop students' awareness of STEM careers	21 (1.2)	24 (1.8)
Incorporate students' cultural backgrounds into science instruction	18 (1.4)	18 (1.5)

Table 13 shows the percentage of classes taught by teachers who feel very well prepared for each of a number of tasks related to instruction in a specific unit. In the majority of high school chemistry classes, teachers feel very well prepared to assess student understanding at the end of a unit, to monitor student understanding during instruction, to implement their designated textbook, and to anticipate student difficulties. For the first two of these areas, chemistry teachers are more likely than all science teachers to feel very well prepared. Also, chemistry teachers are more likely than high school science teachers generally to feel very well prepared to anticipate difficulties students may have with particular science ideas.

Table 13
High School Science Classes in Which Teachers Feel Very Well Prepared for Each of a Number of Tasks in the Most Recent Unit in a Designated Class

	PERCENT OF CLASSES	
	ALL SCIENCES	CHEMISTRY
Assess student understanding at the conclusion of this unit	59 (1.8)	66 (2.6)
Monitor student understanding during this unit	53 (1.8)	60 (2.7)
Implement the instructional materials to be used during this unit	53 (1.6)	56 (2.9)
Anticipate difficulties that students may have with particular science ideas and procedures in this unit	45 (1.6)	55 (2.8)
Find out what students thought or already knew about the key science ideas	38 (1.6)	39 (2.8)

These two sets of items were combined into composite variables. There are no differences between chemistry teachers and high school science teachers overall on either composite (see Table 14).

Table 14
Mean Scores for High School Science Teachers' Perceptions of General and Unit-Specific Pedagogical Preparedness Composites

	MEAN SCORE	
	PEDAGOGICAL PREPAREDNESS	PREPAREDNESS TO IMPLEMENT INSTRUCTION IN PARTICULAR UNIT
All sciences	71 (0.6)	80 (0.5)
Biology	69 (0.9)	80 (0.8)
Chemistry	71 (1.1)	81 (1.0)
Physics	71 (1.4)	79 (1.6)

Pedagogical Beliefs

The survey asked teachers about their beliefs regarding effective teaching and learning in science. As can be seen in Table 15, chemistry teachers hold a number of views that align with what is known about effective science instruction. For example, a large majority of chemistry teachers agree that: (1) teachers 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, and (4) most class periods should provide opportunities for students to share their thinking and reasoning. In addition, fewer than a third of chemistry teachers agree that teachers should explain an idea to students before having them consider evidence that relates to the idea, which is a considerably lower percentage than for all high school science teachers.

However, many chemistry teachers also hold views that are inconsistent with effective science instruction. Close to two-thirds of chemistry teachers believe that students learn best in classes with students of similar abilities and that students should be provided with definitions for new vocabulary at the beginning of instruction on a science idea. In addition, half of chemistry teachers think that hands-on/laboratory activities should be used primarily to reinforce a science idea.

Table 15
High School Science Teachers Agreeing†
With Various Statements About Teaching and Learning

	PERCENT OF TEACHERS	
	ALL SCIENCES	CHEMISTRY
Reform-Oriented Beliefs		
Teachers should ask students to support their conclusions about a science concept with evidence.	99 (0.3)	99 (0.4)
Students learn best when instruction is connected to their everyday lives.	96 (0.7)	95 (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).	93 (1.2)	91 (2.9)
Most class periods should provide opportunities for students to share their thinking and reasoning.	89 (1.4)	90 (2.7)
Most class periods should provide opportunities for students to apply scientific ideas to real-world contexts.	91 (1.4)	87 (2.9)
It is better for science instruction to focus on ideas in depth, even if that means covering fewer topics.	77 (2.0)	77 (2.5)
Traditional Beliefs		
At the beginning of instruction on a science idea, students should be provided with definitions for new scientific vocabulary that will be used.	66 (2.1)	64 (2.4)
Students learn science best in classes with students of similar abilities.	60 (1.7)	61 (3.1)
Hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned.	52 (2.0)	50 (3.1)
Teachers should explain an idea to students before having them consider evidence that relates to the idea.	37 (2.3)	28 (2.4)

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

Table 16 shows average scores on two composites created from these items, one measuring teachers' beliefs aligned with traditional instruction, the other with reform-oriented instruction. The data show remarkable consistency across the subject areas, with high school science teachers generally having fairly strong reform-oriented beliefs and moderate traditional beliefs.

Table 16
Mean Scores for High School Science Teachers'
Beliefs About Teaching and Learning Composites

	MEAN SCORE	
	TRADITIONAL BELIEFS	REFORM-ORIENTED BELIEFS
All sciences	59 (0.7)	85 (0.5)
Biology	59 (1.0)	85 (0.8)
Chemistry	58 (1.0)	85 (0.8)
Physics	56 (1.3)	83 (1.2)

Leadership Roles and Responsibilities

In addition to asking teachers about their involvement as participants in professional development, the survey asked teachers whether they had served in various leadership roles in the profession in the last three years. As can be seen in Table 17, most chemistry teachers have served on a science committee for their school or district. Fewer have provided instructional leadership by (1) observing other teachers and giving feedback or (2) teaching a lesson for others to observe (43 and 40 percent, respectively). Fewer than a third have led or co-led a science-focused professional learning community, served as a formal mentor or coach, or supervised a student teacher.

Table 17
High School Science Teachers Having Various Leadership Responsibilities Within the Last Three Years

	PERCENT OF TEACHERS	
	ALL SCIENCES	CHEMISTRY
Served on a school or district/diocese-wide science committee	51 (2.0)	53 (3.4)
Observed another teacher's science lesson for the purpose of giving them feedback	50 (2.3)	43 (2.8)
Taught a science lesson for other teachers in their school to observe	38 (2.1)	40 (2.9)
Served as a lead teacher or department chair in science	33 (2.0)	38 (3.2)
Led or co-led a workshop or professional learning community for other teachers focused on science or science teaching	28 (1.7)	29 (3.0)
Served as a formal mentor or coach for a science teacher	27 (1.8)	27 (2.3)
Supervised a student teacher in their classroom	22 (2.3)	17 (2.1)

Professional Development of High School Chemistry Teachers

An important measure of teachers' continuing education is how long it has been since they participated in professional development. As can be seen in Table 18, 59 percent of chemistry teachers have participated in science-focused professional development (i.e., focused on science/engineering content or the teaching of science/engineering) in the last 12 months and an additional 26 percent in the preceding 1–3 years. Data for all high school science teachers are quite similar.

Table 18
High School Science Teachers' Most Recent Participation in Science-Focused Professional Development

	PERCENT OF TEACHERS	
	ALL SCIENCES	CHEMISTRY
In the last 12 months	59 (1.8)	59 (2.3)
1–3 years ago	24 (1.5)	26 (2.2)
4–6 years ago	5 (0.8)	5 (0.9)
7–10 years ago	2 (0.4)	2 (0.6)
More than 10 years ago	2 (0.6)	2 (0.7)
Never	7 (0.9)	6 (1.4)

Chemistry teachers, like high school science teachers in general, report low levels of participation in professional development specific to science teaching. Only about one-third have spent more than 35 hours in science-related professional development in the last three years (see Table 19).

Table 19
Time Spent by High School Science Teachers on Science-Focused Professional Development in the Last Three Years

	PERCENT OF TEACHERS	
	ALL SCIENCES	CHEMISTRY
None	18 (1.3)	16 (1.7)
Less than 6 hours	8 (1.3)	7 (1.4)
6–15 hours	18 (1.6)	22 (2.7)
16–35 hours	22 (1.3)	19 (1.7)
36-80 hours	21 (1.4)	22 (2.0)
More than 80 hours	14 (1.0)	13 (1.3)

The most common form of professional development is the workshop, with 86 percent of chemistry teachers who have had professional development attending one in the previous three years (see Table 20). Just over half of chemistry teachers with professional development have participated in a professional learning community or other type of teacher study group.

Table 20
High School Science Teachers Participating in Various Science-Focused Professional Development Activities in the Last Three Years

	PERCENT OF TEACHERS†	
	ALL SCIENCES	CHEMISTRY
Attended a professional development program/workshop	91 (1.5)	86 (3.4)
Participated in a professional learning community/lesson study/teacher study group	55 (1.7)	53 (3.6)
Attended a national, state, or regional science teacher association meeting	40 (2.0)	40 (3.2)
Completed an online course/webinar	34 (2.2)	35 (3.6)
Received assistance or feedback from a formally designated coach/mentor	35 (2.1)	30 (2.8)
Took a formal course for college credit	16 (1.4)	16 (2.3)

† Only high school science teachers indicating that they participated in science-focused professional development in the last three years are included in these analyses.

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, both 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.[6] Accordingly, teachers who had participated in professional development in

[6] 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., and Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. American Educational Research Journal, 38(4), 915–945.

the last three years were asked a series of additional questions about the nature of those experiences.

As can be seen in Table 21, just over half of chemistry teachers who have participated in professional development in the last three years have had substantial opportunity to work closely with other teachers from their school and/or subject, which is similar to all high school science teachers. Relatively few chemistry teachers have had opportunities to (1) examine classroom artifacts, (2) apply what they learned then discuss it further, or (3) rehearse instructional practices as part of their professional development.

Table 21
High School Science Teachers Whose Professional Development in the Last Three Years Had Each of a Number of Characteristics to a Substantial Extent†

	PERCENT OF TEACHERS‡	
	ALL SCIENCES	CHEMISTRY
Worked closely with other teachers from their school	55 (2.3)	55 (3.9)
Worked closely with other teachers who taught the same grade and/or subject whether or not they were from their school	54 (2.1)	52 (4.0)
Had opportunities to experience lessons, as their students would, from the textbook/ modules they use in their classroom	45 (2.4)	46 (3.6)
Had opportunities to engage in science investigations/engineering design challenges	45 (2.4)	44 (3.2)
Had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction)	43 (2.4)	41 (3.3)
Had opportunities to apply what they learned to their classroom and then come back and talk about it as part of the professional development	39 (2.3)	39 (3.1)
Had opportunities to rehearse instructional practices during the professional development (i.e., try out, receive feedback, and reflect on those practices)	35 (2.3)	37 (3.6)

† 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.”

‡ Only high school science teachers indicating that they participated in science-focused professional development in the last three years are included in these analyses.

Another series of items asked about the focus of professional growth opportunities teachers have had in the last three years. Roughly half of chemistry teachers who have participated in professional development in the last three years have had opportunities that gave heavy emphasis to deepening their understanding of how science is done, differentiating instruction to meet the needs of diverse learners, and monitoring student understanding during instruction (see Table 22). Relatively few chemistry teachers have had professional development with a heavy emphasis on several other areas, including implementing instructional materials, deepening their understanding of how engineering is done, or incorporating students’ cultural backgrounds into science instruction.

Table 22
High School Science Teachers Reporting That Their Professional Development in the Last Three Years Gave Heavy Emphasis† to Various Areas

	PERCENT OF TEACHERS‡	
	ALL SCIENCES	CHEMISTRY
Deepening your understanding of how science is done	51 (2.4)	54 (3.5)
Differentiating science instruction to meet the needs of diverse learners	46 (2.0)	48 (4.0)
Monitoring student understanding during science instruction	47 (2.0)	47 (3.7)
Deepening your own science content knowledge	45 (1.9)	45 (3.8)
Learning about difficulties that students may have with particular science ideas	40 (2.0)	42 (3.6)
Finding out what students think or already know prior to instruction on a topic	37 (2.0)	40 (3.8)
Learning how to provide science instruction that integrates engineering, mathematics, and/or computer science	34 (2.1)	36 (3.3)
Implementing the science textbook/module to be used in your classroom	29 (1.9)	28 (2.9)
Deepening your understanding of how engineering is done	23 (1.8)	25 (2.7)
Incorporating students' cultural backgrounds into science instruction	23 (2.1)	23 (3.0)

† 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."

‡ Only high school science teachers indicating that they participated in science-focused professional development in the last three years are included in these analyses.

Responses to items in Table 21 were combined into a composite variable called Extent Professional Development Aligns With Elements of Effective Professional Development. Similarly, the items in Table 22 were combined into a composite variable called Extent Professional Development Supports Student-Centered Instruction. As can be seen in Table 23, scores on both composites are quite similar for the different high school science subjects. The scores also indicate that professional development is only partially aligned with these two constructs.

Table 23
High School Science Teacher Mean Scores for Professional Development Composites

	MEAN SCORE	
	EXTENT PROFESSIONAL DEVELOPMENT ALIGNS WITH ELEMENTS OF EFFECTIVE PROFESSIONAL DEVELOPMENT	EXTENT PROFESSIONAL DEVELOPMENT SUPPORTS STUDENT-CENTERED INSTRUCTION
All sciences	55 (1.1)	52 (0.8)
Biology	55 (1.5)	53 (1.2)
Chemistry	54 (1.7)	53 (1.7)
Physics	52 (2.0)	51 (2.0)

High School Chemistry Courses Offered

Of the high schools in the United States (schools including grades 9, 10, 11, or 12), almost all offer at least one chemistry course (see Table 24). Seventy-two percent offer a 1st year chemistry course, and 45 percent offer a 2nd year course. Just over a third of high schools offer Advanced Placement (AP) Chemistry. The percentage of high school students with access to AP Chemistry is much larger than the percentage of high schools offering the course, most likely because large schools are more likely than small ones to offer advanced chemistry courses and because small schools outnumber large schools in the United States. Very few schools offer the International Baccalaureate (IB) chemistry course.

Table 24
Access to Chemistry Courses at High Schools, by Schools and Students

	PERCENT OF HIGH SCHOOLS OFFERING	PERCENT OF HIGH SCHOOL STUDENTS WITH ACCESS
Any level	94 (1.9)	98 (0.5)
Non-college prep	58 (3.0)	62 (2.4)
1st year college prep, including honors	72 (3.3)	89 (1.4)
2nd year advanced	45 (3.3)	74 (2.3)
AP Chemistry	36 (2.8)	65 (2.4)
IB Chemistry	2 (0.5)	6 (1.2)

In terms of the percentage of classes offered in the nation, chemistry (any level) accounts for 22 percent of all high school science classes (see Table 25). This percentage ranks second behind biology (38 percent).

Table 25
Most Commonly Offered High School Science Courses

	PERCENT OF CLASSES
Life Science/Biology	
Non-college prep	7 (0.9)
1st year college prep, including honors	22 (1.4)
2nd year advanced	8 (1.3)
Chemistry	
Non-college prep	3 (0.5)
1st year college prep, including honors	16 (1.1)
2nd year advanced	3 (0.5)
Physics	
Non-college prep	2 (0.4)
1st year college prep, including honors	8 (0.8)
2nd year advanced	2 (0.4)
Earth Space/Science	
Non-college prep	3 (0.8)
1st year college prep, including honors	2 (0.5)
2nd year advanced	0 (0.2)
Environmental Science/Ecology	
Non-college prep	3 (0.6)
1st year college prep, including honors	2 (0.6)
2nd year advanced	2 (0.4)
Multi-Discipline Science Courses (including General Science and Physical Science)	
Non-college prep	8 (0.8)
1st year college prep, including honors	5 (0.8)
2nd year advanced	1 (0.4)

The typical chemistry class has approximately 21 students; two-thirds of the classes have between 13 and 28 students. Fifty-one percent of chemistry students are female, the same as biology but considerably higher than physics (see Table 26). Further, although students from race/ethnicity groups historically underrepresented in STEM[7] make up about half of the student population, only 35 percent of students who take 1st year chemistry are from these groups.

Table 26
Demographics of Students in 1st Year High School Science Courses

	PERCENT OF STUDENTS	
	FEMALE	HISTORICALLY UNDERREPRESENTED
1st Year Biology	51 (1.5)	35 (3.0)
1st Year Chemistry	51 (1.1)	35 (2.2)
1st Year Physics	41 (1.9)	30 (3.0)

7 Includes students identified as American Indian or Alaskan Native, Black or African American, Hispanic or Latino, or Native Hawaiian or Other Pacific Islander.

Chemistry classes are similar to biology classes in terms of the prior achievement level of students (see Table 27). In contrast, chemistry classes are considerably less likely than physics classes to be composed of high-achieving students.

Table 27
Prior Achievement Grouping in 1st Year High School Science Courses

	PERCENT OF CLASSES			
	MOSTLY LOW ACHIEVERS	MOSTLY AVERAGE ACHIEVERS	MOSTLY HIGH ACHIEVERS	A MIXTURE OF LEVELS
1st Year Biology	9 (1.8)	32 (4.1)	29 (4.2)	30 (3.5)
1st Year Chemistry	5 (0.9)	32 (2.4)	32 (2.6)	31 (2.7)
1st Year Physics	6 (1.7)	24 (3.2)	42 (5.0)	28 (4.5)

High School Chemistry Instruction

This section of the report draws on teachers' descriptions of what transpires in chemistry classrooms, in terms of teachers' autonomy for making decisions regarding the content and pedagogy of their classes, instructional objectives, and class activities.

Teachers' Perceptions of Their Decision-Making Autonomy

Teachers were asked about the extent to which they had control over a number of curricular and instructional decisions for their classes. Similar to high school science classes overall, in chemistry classes teachers are likely to perceive themselves as having strong control over pedagogical decisions, such as determining the amount of homework to be assigned, selecting teaching techniques, and choosing criteria for grading student performance (see Table 28). In fewer classes, teachers perceive themselves as having strong control in determining course goals and objectives; selecting curriculum materials; and selecting content, topics, and skills to be taught.

Table 28
High School Science Classes in Which Teachers Report
Having Strong Control Over Various Curricular and Instructional Decisions

	PERCENT OF CLASSES	
	ALL SCIENCES	CHEMISTRY
Determining the amount of homework to be assigned	74 (1.8)	77 (2.6)
Selecting teaching techniques	68 (2.3)	72 (2.4)
Choosing criteria for grading student performance	54 (2.2)	57 (3.4)
Determining the amount of instructional time to spend on each topic	48 (2.1)	55 (3.1)
Selecting the sequence in which topics are covered	51 (2.1)	52 (3.5)
Determining course goals and objectives	36 (2.5)	37 (3.6)
Selecting curriculum materials (e.g., textbooks/modules)	36 (2.0)	35 (2.3)
Selecting content, topics, and skills to be taught	34 (2.2)	34 (3.7)

These items were combined into two composite variables: Curriculum Control and Pedagogy Control. Scores on both composites are not significantly different from the mean scores for other science classes, but the mean for Pedagogy Control is considerably higher than the mean for Curriculum Control (see Table 29).

Table 29
High School Science Class Mean Scores for Curriculum Control and Pedagogy Control Composites

	MEAN SCORE	
	CURRICULUM CONTROL	PEDAGOGY CONTROL
All sciences	67 (1.4)	87 (1.0)
Biology	65 (2.4)	86 (2.0)
Chemistry	68 (1.9)	88 (0.9)
Physics	69 (2.7)	89 (1.7)

Instructional Objectives

Teachers were given a list of potential objectives and asked to rate each in terms of the emphasis they receive in the randomly selected class. As can be seen in Table 30, chemistry classes are quite similar to high school science classes in general with the exception of understanding science concepts, which chemistry classes are more likely to emphasize. All science classes are far more likely to emphasize this objective than any other. Classes are relatively unlikely to give heavy emphasis to several objectives, including increasing student interest in science/engineering, learning science vocabulary and/or facts, learning about real-life applications, and learning about different fields of science and engineering.

Table 30
High School Science Classes With Heavy Emphasis on Various Instructional Objectives

	PERCENT OF CLASSES	
	ALL SCIENCES	CHEMISTRY
Understanding science concepts	76 (1.8)	84 (2.2)
Learning how to do science (develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)	41 (1.3)	45 (2.9)
Developing students' confidence that they can successfully pursue careers in science/engineering	35 (1.5)	41 (2.3)
Increasing students' interest in science/engineering	31 (1.5)	31 (2.8)
Learning science vocabulary and/or facts	32 (1.6)	27 (2.6)
Learning about real-life applications of science/engineering	29 (1.2)	24 (2.5)
Learning test-taking skills/strategies	23 (1.4)	24 (2.5)
Learning about different fields of science/engineering	7 (0.8)	6 (1.0)
Learning how to do engineering (e.g., identify criteria and constraints, design solutions, optimize solutions)	5 (0.7)	6 (1.1)

The objectives related to reform-oriented instruction (understanding science concepts, learning about different fields of science/engineering, learning how to do science, learning how to do engineering, learning about real-life applications of science/engineering, increasing students' interest in science/engineering, and developing students' confidence that they can successfully pursue careers in science/engineering) were combined into a composite variable. Scores on this composite are the same as for all high school science classes in general; however, the mean for chemistry is higher than the mean for biology and lower than the mean for physics (see Table 31).

Table 31
High School Science Class Mean Scores for the Reform-Oriented Instructional Objectives Composite

	MEAN SCORE
All Sciences	65 (0.5)
Biology	63 (1.1)
Chemistry	66 (0.8)
Physics	70 (1.1)

Class Activities

The 2018 NSSME+ included several items that provide information about how chemistry is taught at the high school level. One series of items listed various instructional strategies and asked teachers to indicate the frequency with which they used each in a randomly selected class. As can be seen in Table 32, the vast majority of chemistry classes include the teacher explaining science ideas, students working in small groups, and whole class discussions on a weekly basis. Seventy percent of classes engage students in hands-on/laboratory activities at least once a week. It is somewhat striking that, in contrast to what is known from learning theory about the importance of reflection, only about a quarter of chemistry classes have students write reflections on what they are learning once a week or more.

Table 32
High School Science Classes in Which Teachers Report Using Various Activities at Least Once a Week

	PERCENT OF CLASSES	
	ALL SCIENCES	CHEMISTRY
Explain science ideas to the whole class	92 (0.9)	94 (1.4)
Have students work in small groups	84 (1.5)	89 (2.1)
Engage the whole class in discussions	78 (1.3)	78 (2.4)
Have students do hands-on/laboratory activities	68 (1.6)	70 (2.7)
Focus on literacy skills (e.g., informational reading or writing strategies)	33 (1.6)	27 (2.8)
Have students write their reflections (e.g., in their journals, on exit tickets) in class or for homework	28 (1.4)	27 (2.1)
Engage the class in project-based learning (PBL) activities	28 (1.7)	23 (2.7)
Have students practice for standardized tests	20 (1.5)	19 (2.3)
Have students read from a textbook, module, or other material in class, either aloud or to themselves	26 (1.7)	18 (2.4)
Use flipped instruction (have students watch lectures/demonstrations outside of class to prepare for in-class activities)	15 (1.3)	15 (2.1)

The survey also asked how often students in science classes are engaged in doing science as described in documents like *A Framework for K–12 Science Education*[8]—i.e., the practices of science, such as formulating scientific questions, designing and implementing investigations,

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

developing models and explanations, and engaging in argumentation. As can be seen in Table 33, students often engage in aspects of science related to conducting investigations and analyzing data. For example, half or more chemistry classes have students organize and represent data, conduct scientific investigations, analyze data, and make and support claims with evidence at least once a week.

However, students tend to not be engaged very often in aspects of science related to evaluating the strengths and limitations of evidence and the practice of argumentation. For example, fewer than a quarter of chemistry classes have students, at least once a week, pose questions about scientific arguments, evaluate the credibility of scientific information, identify strengths and limitations of a scientific model, evaluate the strengths and weaknesses of competing scientific explanations, determine what details about an investigation might persuade a targeted audience about a scientific claim, or construct a persuasive case.

At the same time, chemistry classes are more likely than other high school science classes to engage students in some practices, including analyzing data, considering the impacts of missing data or measurement error, selecting and using appropriate mathematical or statistical techniques, and using mathematical or computational models to support claims.

Table 33
High School Science Classes in Which Teachers Report Students Engaging in Various Aspects of Science Practices at Least Once a Week

	PERCENT OF CLASSES	
	ALL SCIENCES	CHEMISTRY
Organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data	58 (1.5)	61 (2.8)
Conduct a scientific investigation	50 (1.6)	54 (3.0)
Analyze data using grade-appropriate methods in order to identify patterns, trends, or relationships	47 (1.4)	54 (2.8)
Make and support claims with evidence	50 (1.5)	50 (2.5)
Determine what data would need to be collected in order to answer a scientific question	39 (1.4)	45 (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	36 (1.5)	42 (2.7)
Consider how missing data or measurement error can affect the interpretation of data	27 (1.5)	40 (2.7)
Generate scientific questions	38 (1.8)	39 (2.6)
Select and use grade-appropriate mathematical and/or statistical techniques to analyze data	30 (1.6)	37 (2.8)
Develop procedures for a scientific investigation to answer a scientific question	32 (1.4)	36 (2.6)
Use mathematical and/or computational models to generate data to support a scientific claim	26 (1.3)	36 (2.3)
Develop scientific models—physical, graphical, or mathematical representations of real-world phenomena	34 (1.5)	35 (2.6)
Revise their explanations based on additional evidence	28 (1.4)	31 (2.6)
Summarize patterns, similarities, and differences in scientific information obtained from multiple sources	28 (1.5)	31 (2.5)
Use multiple sources of evidence to develop an explanation	33 (1.6)	30 (2.6)
Determine whether or not a question is scientific	28 (1.5)	29 (2.6)
Use data and reasoning to defend, verbally or in writing, a claim or refute alternative scientific claims	27 (1.7)	25 (2.4)
Identify the strengths and limitations of a scientific model—in terms of accuracy, clarity, generalizability, accessibility to others, strength of evidence supporting it	22 (1.1)	25 (2.2)
Pose questions that elicit relevant details about the important aspects of a scientific argument	23 (1.6)	22 (2.5)
Evaluate the credibility of scientific information—e.g., its reliability, validity, consistency, logical coherence, lack of bias, or methodological strengths and weaknesses	23 (1.4)	20 (2.4)
Evaluate the strengths and weaknesses of competing scientific explanations	20 (1.6)	20 (2.2)
Determine what details about an investigation might persuade a targeted audience about a scientific claim	17 (1.3)	16 (2.0)
Construct a persuasive case, verbally or in writing, for the best scientific model or explanation for a real-world phenomenon	15 (1.1)	15 (2.0)

These items were combined into a composite variable titled Engaging Students in the Practices of Science. The scores on this composite indicate that chemistry students, and high school science students in general, engage in this set of practices, on average, just once or twice a month or less.

Table 34
High School Science Class Mean Scores for Engaging Students in the Practices of Science Composite

	MEAN SCORE
All Sciences	50 (0.6)
Biology	49 (1.1)
Chemistry	51 (1.0)
Physics	52 (1.4)

Given recent trends to incorporate engineering and computer science into science instruction, the 2018 NSSME+ asked teachers how frequently they do so. As can be seen in Table 35, the typical chemistry class experiences engineering a few times per year (49 percent of classes), which is similar to all other sciences. Fewer than a third of chemistry classes incorporate engineering at least monthly. In terms of coding, a large majority of chemistry classes never include coding, which is again similar to high school science classes in general.

Table 35
High School Science Classes in Which Teachers Report Incorporating Engineering and Coding Into Science Instruction

	PERCENT OF CLASSES	
	ALL SCIENCES	CHEMISTRY
Engineering		
Never	20 (1.8)	22 (2.7)
Rarely (e.g., a few times per year)	50 (1.9)	49 (3.0)
Sometimes (e.g., once or twice a month)	24 (1.5)	23 (2.9)
Often (e.g., once or twice a week)	6 (1.1)	5 (1.6)
All or almost all science lessons	1 (0.2)	1 (0.3)
Coding		
Never	89 (1.2)	86 (2.6)
Rarely (e.g., a few times per year)	6 (0.9)	8 (1.6)
Sometimes (e.g., once or twice a month)	4 (0.8)	6 (2.2)
Often (e.g., once or twice a week)	0 (0.1)	0 (0.3)
All or almost all science lessons	0 (0.0)	0 (0.1)

In addition to asking about class activities in the course as a whole, the 2018 NSSME+ asked teachers about activities that took place during their most recent science lesson in the randomly selected class. More than 8 in 10 chemistry classes include students working in small groups or the teacher explaining a science idea to the whole class in the most recent lesson (see Table 36). Students completing textbook/worksheet problems and whole class discussion each occur in 59 percent of chemistry lessons. Students completing worksheets is much more common in chemistry classes than in high school science classes generally (59 and 44 percent, respectively), and students reading about science is less common (22 and 39 percent, respectively). In addition, chemistry classes are less likely than other science classes to include students writing about science (20 and 34 percent, respectively) and reading about science (15 and 33 percent, respectively).

Table 36
High School Science Classes Participating in Various Activities in Most Recent Lesson

	PERCENT OF CLASSES	
	ALL SCIENCES	CHEMISTRY
Students working in small groups	81 (1.4)	87 (1.7)
Teacher explaining a science idea to the whole class	81 (1.3)	85 (1.9)
Whole class discussion	59 (1.6)	59 (2.9)
Students completing textbook/worksheet problems	44 (1.6)	59 (3.2)
Teacher conducting a demonstration while students watched	31 (1.6)	38 (2.7)
Students doing hands-on/laboratory activities	40 (1.6)	37 (2.5)
Students writing about science	34 (1.8)	20 (1.9)
Test or quiz	16 (1.2)	19 (2.1)
Students reading about science	33 (1.6)	15 (2.3)
Practicing for standardized tests	8 (0.9)	12 (2.1)

The survey also asked teachers to estimate the time spent on each of a number of types of activities in this most recent science lesson. There is essentially no difference between chemistry and science classes in general (see Table 37). Whole class activities and small group work each make up slightly less than 40 percent of class time, and 16 percent is spent on students working individually. Non-instructional activities, including attendance taking and interruptions, account for less than 10 percent of science class time.

Table 37
Average Percentage of Time Spent on Different Activities in the Most Recent High School Science Lesson

	AVERAGE PERCENT OF CLASS TIME	
	ALL SCIENCES	CHEMISTRY
Whole class activities (e.g., lectures, explanations, discussions)	38 (0.8)	38 (1.2)
Small group work	34 (0.8)	37 (1.2)
Students working individually (e.g., reading textbooks, completing worksheets, taking a test or quiz)	19 (0.8)	16 (1.1)
Non-instructional activities (e.g., attendance taking, interruptions)	10 (0.2)	9 (0.3)

Homework and Assessment Practices

Teachers were asked about the amount of homework assigned per week in the randomly selected class. As can be seen in Table 38, most chemistry classes assign between 31 and 90 minutes of homework per week, which is similar to all science classes.

Table 38
Amount of Homework Assigned in High School Science Classes Per Week

	PERCENT OF CLASSES	
	ALL SCIENCES	CHEMISTRY
None	3 (0.5)	1 (0.9)
1–15 minutes per week	9 (1.3)	7 (2.0)
15–30 minutes per week	19 (1.3)	14 (2.4)
31–60 minutes per week	33 (1.6)	34 (3.6)
61–90 minutes per week	22 (1.9)	24 (3.0)
91–120 minutes per week	7 (0.9)	10 (1.8)
More than 2 hours per week	7 (0.9)	10 (2.5)

The survey also asked how often students in the randomly selected class were required to take assessments that teachers did not develop, such as state or district benchmark assessments. Two-thirds of chemistry classes are required to take such an assessment at least once a year, roughly equivalent to high school science classes in general (see Table 39).

Table 39
Frequency of Required External Testing in High School Science Classes

	PERCENT OF CLASSES	
	ALL SCIENCES	CHEMISTRY
Never	31 (2.0)	32 (3.3)
Once a year	33 (2.0)	34 (3.0)
Twice a year	14 (1.7)	15 (3.0)
Three or four times a year	16 (1.5)	16 (1.8)
Five or more times a year	6 (0.9)	4 (1.0)

Resources Available for High School Chemistry

The quality and availability of instructional resources are major factors affecting science teaching. The 2018 NSSME+ included a series of items on instructional materials—which ones teachers use and how teachers use them—as well as the adequacy of other resources for their science instruction.

Instructional Materials

The survey collected data on the use of instructional materials in science classes. In just over half of chemistry classes, the district designates instructional materials to be used (see Table 40).

Table 40
High School Science Classes for Which the District Designates Instructional Materials to Be Used

	PERCENT OF CLASSES
All Sciences	58 (2.0)
Chemistry	56 (2.9)

When teachers responded that their randomly selected class had a designated instructional material, the survey presented them with a list of possible types of materials. Despite the increasing variety of instructional materials, it is clear that in chemistry, like high school science in general, the textbook still dominates (see Table 41). The data also indicate that for many classes, multiple types of materials are being designated.

Table 41
High School Science Classes for Which Various Types of Instructional Resources Are Designated

	PERCENT OF CLASSES†	
	ALL SCIENCES	CHEMISTRY
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	95 (0.9)	96 (1.4)
State, county, district, or diocese-developed units or lessons	27 (1.7)	31 (3.1)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	25 (2.0)	25 (2.6)
Commercially published kits/modules (printed or electronic)	22 (2.0)	20 (2.6)
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)	16 (1.5)	18 (2.4)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)	11 (1.8)	9 (1.8)

† Only high school 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. As can be seen in Table 42, teacher-created units or lessons are by far the most likely to be used on a weekly basis in chemistry classes. Commercially published textbooks and units or lessons from any other source are a distant second, with all the rest being relatively uncommon.

Table 42
High School Science Classes Basing Instruction on Various Instructional Resources at Least Once a Week

	PERCENT OF CLASSES	
	ALL SCIENCES	CHEMISTRY
Units or lessons you created (either by yourself or with others)	86 (1.0)	85 (2.0)
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	50 (1.7)	47 (3.0)
Units or lessons you collected from any other source (e.g., conferences, journals, colleagues, university or museum partners)	49 (1.7)	47 (2.7)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	31 (1.8)	26 (2.3)
Commercially published kits/modules (printed or electronic)	21 (1.5)	20 (2.5)
State, county, district, or diocese-developed units or lessons	14 (1.2)	14 (1.7)
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)	16 (1.1)	12 (1.7)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)	9 (1.0)	6 (1.3)

Teachers who indicated that the randomly selected class used commercially published materials were asked to record the title, author, year, and ISBN of the material used most often in the class. Using this information, the publisher of the material was identified. The most commonly used chemistry materials are:

- *Chemistry* (Pearson);
- *Modern Chemistry* (Houghton Mifflin Harcourt);
- *Chemistry* - *Matter and Change* (McGraw-Hill);
- *Chemistry* - *The Central Science* (Pearson); and
- *Chemistry* (Cengage).

Table 43 shows the publication year of commercially published instructional materials used. Half of high school chemistry classes use materials published in 2009 or earlier. Fewer than a third use materials published in the last five years.

Table 43
Publication Year of Textbooks Used in High School Science Classes

	PERCENT OF CLASSES†	
	ALL SCIENCES	CHEMISTRY
2009 or earlier	43 (2.1)	51 (3.3)
2010–12	27 (1.9)	22 (2.7)
2013–15	20 (1.8)	19 (2.5)
2016–18	9 (1.4)	8 (1.8)

† Only high school science classes using commercially published textbooks/modules are included in these analyses.

Teachers were also asked whether the most recent unit in their randomly selected class was based primarily on either a commercially published textbook or materials developed by the state or district. As shown in Table 44, most recent units in just over half of chemistry classes are based on such materials.

Table 44
High School Science Classes in Which the Most Recent Unit Was Based on a Commercially Published Textbook or a Material Developed by the State or District

	PERCENT OF CLASSES†
All Sciences	54 (1.9)
Chemistry	52 (3.5)

† Only high school science classes using commercially published or state/district-developed materials at least once a month are included in these analyses.

When teachers responded that their most recent unit was based on one of these materials, they were asked how they used the material (see Table 45). Two important findings emerge from these data. First, it is clear that when classes use commercially published and state/district-developed materials, teachers modify their materials substantially in designing instruction. In 80 percent of chemistry classes, teachers incorporate activities from other sources substantially; in 68 percent, they modify activities from the materials, and in 53 percent, they "pick and choose" from the material. Second, the materials heavily influence instruction. Teachers in just over 70 percent of chemistry classes use the textbook substantially to guide the overall structure and content emphasis of their units, which is similar to all science classes.

Table 45
Ways High School Science Teachers Substantially† Used Their Materials in the Most Recent Unit

	PERCENT OF CLASSES‡	
	ALL SCIENCES	CHEMISTRY
I incorporated activities (e.g., problems, investigations, readings) from other sources to supplement what these materials were lacking.	78 (2.1)	80 (3.7)
I used these materials to guide the structure and content emphasis of the unit.	76 (2.0)	71 (3.7)
I modified activities from these materials.	71 (2.7)	68 (4.5)
I picked what is important from these materials and skipped the rest.	53 (2.6)	53 (4.2)

† 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.”
‡ Only high school science classes in which the most recent unit was based on commercially published or state/district-developed materials are included in these analyses.

Teachers were also asked why they skipped parts of their textbook/module. As can be seen in Table 46, teachers in 76–78 percent of these chemistry classes skip activities because (1) they have other ones that work better, (2) the ideas addressed are not in the pacing guide or standards, or (3) they did not have enough instructional time. Other common reasons for skipping activities include students already knowing the content (57 percent), the activities being too difficult (54 percent), and the teacher not having the materials needed (43 percent).

Table 46
Reasons Why Parts of High School Science Materials Are Skipped

	PERCENT OF CLASSES†	
	ALL SCIENCES	CHEMISTRY
I have different activities for those science ideas that work better than the ones I skipped.	77 (4.0)	78 (3.3)
The science ideas addressed in the activities I skipped are not included in my pacing guide/standards.	73 (3.2)	77 (3.7)
I did not have enough instructional time for the activities I skipped.	74 (3.5)	76 (3.8)
My students already knew the science ideas or were able to learn them without the activities I skipped.	52 (3.5)	57 (4.4)
The activities I skipped were too difficult for my students.	59 (3.4)	54 (3.6)
I did not have the materials needed to implement the activities I skipped.	54 (3.7)	43 (4.0)
I did not have the knowledge needed to implement the activities I skipped.	20 (2.6)	17 (3.6)

† Only high school science classes in which (1) the most recent unit was based on commercially published or state/district-developed materials and (2) teachers reported skipping some activities are included in these analyses.

Teachers in nearly all chemistry classes that supplement their textbook/module do so to provide students with additional practice (see Table 47). Similarly, teachers in about 9 out of 10 chemistry classes that supplement are trying to help students at different levels of achievement learn targeted ideas or because they have additional activities they like. Preparing students for standardized tests is also a common reason for supplementing (64 percent of classes).

Table 47
Reasons Why High School Science Materials Are Supplemented

	PERCENT OF CLASSES†	
	ALL SCIENCES	CHEMISTRY
Supplemental activities were needed to provide students with additional practice.	86 (3.7)	96 (1.4)
Supplemental activities were needed so students at different levels of achievement could increase their understanding of the ideas targeted in each activity.	86 (3.5)	93 (2.3)
I had additional activities that I liked.	88 (2.6)	91 (2.6)
Supplemental activities were needed to prepare students for standardized tests.	53 (3.6)	64 (5.0)
My pacing guide indicated that I should use supplemental activities.	46 (3.3)	51 (5.6)

† Only high school science classes in which (1) the most recent unit was based on commercially published or state/district-developed materials and (2) teachers reported supplementing some activities are included in these analyses.

Finally, when teachers reported that they modified their published material (which more than two-thirds did), they rated each of several factors that may have contributed to their decision (see Table 48). Two factors stand out: teachers do not have enough time to implement the activities as designed (71 percent of classes), and the activities are too difficult for students (50 percent of classes).

Table 48
Reasons Why High School Science Materials Are Modified

	PERCENT OF CLASSES†	
	ALL SCIENCES	CHEMISTRY
I did not have enough instructional time to implement the activities as designed.	71 (2.8)	71 (3.7)
The original activities were too difficult conceptually for my students.	58 (3.3)	50 (4.7)
The original activities were not structured enough for my students.	40 (3.5)	43 (4.9)
I did not have the necessary materials/supplies for the original activities.	53 (3.4)	42 (5.1)
The original activities were too easy conceptually for my students.	44 (3.6)	40 (4.5)
The original activities were too structured for my students.	38 (3.1)	36 (4.6)

† Only high school science classes in which (1) the most recent unit was based on commercially published or state/district-developed materials and (2) teachers reported modifying some activities are included in these analyses.

Other High School Chemistry Instructional Resources

Science teachers were presented with a list of general instructional technologies as indicators of whether classes have access to basic resources for science instruction and asked about availability in their randomly selected class (either always in the classroom or upon request). The percentages of chemistry classes with at least some availability of these resources are shown in Table 49. More than 90 percent of chemistry classes have access to projection devices, balances and microscopes, and 85 percent have access to probes for collecting data.

Table 49
Availability† of Instructional Resources in High School Science Classes

	PERCENT OF CLASSES	
	ALL SCIENCES	CHEMISTRY
Projection devices (e.g., Smartboard, document camera, LCD projector)	98 (0.8)	98 (1.2)
Balances (e.g., pan, triple beam, digital scale)	97 (0.8)	98 (1.3)
Microscopes	94 (1.0)	91 (2.3)
Probes for collecting data (e.g., motion sensors, temperature probes)	81 (2.3)	85 (2.6)

† Includes high school science teachers indicating the resource is always available in their classroom or available upon request.

Science teachers were also asked about the availability of laboratory facilities, either in their classroom or in another room. Electrical outlets and running water are available to nearly all chemistry classrooms (see Table 50). Not surprisingly, chemistry classes are more likely than science classes in general to have access to gas for burners (92 vs. 83 percent).

Table 50
Availability† of Laboratory Facilities in High School Science Classes

	PERCENT OF CLASSES	
	ALL SCIENCES	CHEMISTRY
Electric outlets	98 (0.6)	99 (1.1)
Faucets and sinks	94 (1.1)	99 (1.1)
Lab tables	95 (0.9)	96 (1.7)
Gas for burners	82 (1.8)	92 (2.1)
Fume hoods	85 (1.7)	90 (2.7)

† Includes high school science teachers indicating the resource is located in the classroom or available in another room.

When asked about the adequacy of resources for instruction, teachers in three-fourths or more of high school chemistry classes rated their facilities, access to consumable supplies and equipment, and instructional technology as adequate (see Table 51). On a composite variable created from these items titled "Adequacy of Resources for Instruction," chemistry classes have a higher mean score than science classes in general (see Table 52).

Table 51
Adequacy† of Resources for High School Science Instruction

	PERCENT OF CLASSES	
	ALL SCIENCES	CHEMISTRY
Facilities (e.g., lab tables, electric outlets, faucets and sinks)	72 (2.0)	80 (3.1)
Equipment (e.g., thermometers, magnifying glasses, microscopes, beakers, photogate timers, Bunsen burners)	73 (1.9)	79 (2.3)
Consumable supplies (e.g., chemicals, living organisms, batteries)	67 (2.1)	76 (2.4)
Instructional technology (e.g., calculators, computers, probes/sensors)	70 (2.1)	75 (2.8)

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

Table 52
High School Science Class Mean Scores for the Adequacy of Resources for Instruction Composite

	MEAN SCORE
All Sciences	76 (1.1)
Biology	76 (2.0)
Chemistry	81 (1.6)
Physics	78 (2.4)

Factors Affecting High School Chemistry Instruction

Although the primary focus of the 2018 NSSME+ was on teachers and teaching, the study also collected information on the context of classroom practice. Teachers were asked about factors that potentially inhibit or promote instruction in their randomly selected class.

As can be seen in Table 53, in the majority of chemistry classes, teachers think that most of the factors promote effective instruction, including time to plan; principal support; students' motivation, interest, and effort in science; college entrance requirements; students' prior knowledge and skills; current state standards; and pacing guides. Time for professional development, parent/guardian expectations and involvement, teacher evaluation policies, textbook selection policies, and accountability policies, among others, are seen as promoting effective instruction in fewer than half of chemistry classes.

Table 53
Factors Promoting† Effective Instruction in High School Science Classes

	PERCENT OF CLASSES	
	ALL SCIENCES	CHEMISTRY
Amount of time for you to plan, individually and with colleagues	69 (2.2)	68 (3.5)
Principal support	66 (1.9)	67 (2.7)
Students' motivation, interest, and effort in science	60 (1.9)	61 (2.9)
College entrance requirements	53 (2.1)	61 (3.1)
Students' prior knowledge and skills	59 (2.2)	55 (2.8)
Current state standards	55 (2.2)	55 (2.8)
Pacing guides	48 (2.3)	51 (3.7)
Amount of time available for your professional development	52 (2.2)	49 (3.0)
Parent/guardian expectations and involvement	43 (2.6)	42 (3.8)
Teacher evaluation policies	42 (2.3)	40 (3.5)
Textbook/module selection policies	38 (2.5)	36 (3.1)
State/district/diocese testing/accountability policies‡	29 (1.8)	31 (3.2)

† Includes high school science teachers indicating 4 or 5 on a five-point scale ranging from 1 "inhibits effective instruction" to 5 "promotes effective instruction."
‡ This item was presented only to teachers in public and Catholic schools.

Three composites from these questionnaire items were created to summarize the extent to which various factors support effective instruction: (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 means are shown in Table 54 and are strikingly similar for chemistry classes and all other sciences. Overall, the means suggest a somewhat positive environment for science instruction in terms of school support, stakeholder support, and policy environment.

Table 54
High School Science Class Mean Scores for Factors Affecting Instruction Composites

	PERCENT OF CLASSES			
	ALL SCIENCES	BIOLOGY	CHEMISTRY	PHYSICS
Extent to Which School Support Promotes Effective Instruction	69 (1.5)	69 (2.7)	68 (1.9)	69 (2.9)
Extent to Which Stakeholders Promote Effective Instruction	64 (1.0)	64 (2.1)	64 (1.6)	69 (2.4)
Extent to Which the Policy Environment Promotes Effective Instruction	61 (0.8)	60 (1.5)	61 (1.4)	62 (2.5)

Summary

Like high school science teachers in general, 9 in 10 high school chemistry teachers are white, and the majority (58 percent) are female. In terms of teaching experience, chemistry teachers reflect the high school teacher population; about a quarter are in their first five years of teaching science, and slightly more than one-fifth have more than 20 years of experience. Chemistry teachers are more likely than Earth/space science, ecology/environmental science, and physics teachers to be certified in their subject area, and they are slightly more likely than high school science teachers in general to have a degree in science. They are less likely than biology teachers, but considerably more likely than physics teachers, to have a degree in their subject. Chemistry teachers are more likely to feel prepared to teach their subject than both biology teachers and physics teachers. However, fewer than 10 percent of chemistry teachers feel very well prepared to teach engineering concepts.

In terms of pedagogical preparedness, chemistry teachers are similar to high school science teachers more broadly. The majority feel very well prepared to develop students' conceptual understanding and to use formative assessment, but fewer than half feel very well prepared to develop students' abilities to do science, encourage student interest, differentiate instruction to meet the needs of diverse learners, or incorporate students' cultural backgrounds into instruction. In addition, data on chemistry teachers' beliefs about effective teaching show a dichotomy. On one hand, a large majority hold a number of beliefs about teaching and learning that align with what is known about effective science instruction (e.g., teachers should ask students to support conclusions with evidence; students should learn science by doing science). On the other hand, a substantial proportion hold views inconsistent with this research. For example, almost two-thirds of chemistry teachers believe that students should be provided with definitions for new vocabulary at the beginning of instruction on an idea, and half believe that hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned.

When asked about their professional development experiences, a large majority of high school chemistry teachers report participating in science-focused professional development in the last three years. However, only about one-third have had sustained professional development (more than 35 hours) in that time period. The majority of chemistry teachers attending professional development indicate that it had a heavy focus on deepening their understanding of how science is done, and for just under half, their professional development had a heavy emphasis on differentiating instruction for diverse learners, monitoring student understanding, and deepening their own science content knowledge.

Data on chemistry courses indicate that nearly all students in the nation have access to one or more chemistry courses at their schools, though only about two-thirds have access to an AP Chemistry course. However, although students from race/ethnicity groups historically underrepresented constitute about half of the student population, they represent only about a third of the enrollment in 1st year college prep science courses, including chemistry.

Data on instruction indicate that chemistry classes rely heavily on lecture and discussion, though students are engaged in hands-on/laboratory activities frequently as well. In terms of engagement with the practices of science, students in chemistry classes, like those in high school science more generally, tend to be engaged in aspects of science related to conducting investigations and analyzing data. However, they tend not be engaged in aspects of science related to evaluating the strength and limitations of evidence or the practice of argumentation.

The vast majority of chemistry classes base instruction on teacher-developed lessons on a weekly basis; fewer than half of chemistry classes base instruction on commercially published materials weekly. When teachers do use textbooks, they often modify the materials, supplementing and skipping elements for a variety of reasons. In terms of other resources for instruction, nearly all chemistry classes have access to needed laboratory facilities, and the large majority of chemistry teachers think their access to technology, equipment, and consumable supplies is adequate.