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2018 NSSME+: Status of High School Physics

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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/

TABLE OF CONTENTS

Page

LIST OF TABLES

High School Physics Instruction

Resources Available for High School Physics

Factors Affecting High School Physics Instruction

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) physics instruction based on the responses of 479 physics 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 chemistry 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 physics and other science classes may have been asked about any of those classes. Accordingly, the number of physics classes included in the analyses reported below (309) is smaller than the number of responding teachers of physics. Generally, the larger standard errors are a reflection of the reduced sample size.

Details 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 physics teaching is organized into major topical areas:

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

High School Physics 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 physics teachers, including their course backgrounds, beliefs about teaching and learning, and perceptions of preparedness.

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

2 Detailed information for high school chemistry and biology teachers can be found in *2018 NSSME+: Status of High School Chemistry* (Smith, 2019) and *2018 NSSME+: Status of High School Biology* (Wingard, 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

Compared to high school science teachers in general, physics teachers are much more likely to be male than female (see Table 1), though similar in terms of race/ethnicity—the overwhelming majority are white. Nearly a third of physics teachers are in their first five years of teaching, and a fifth have 21 or more years of teaching experience.

Table 1
Characteristics of the High School Science Teaching Force

	PERCENT OF TEACHERS	
	ALL SCIENCES	PHYSICS
Sex		
Female	57 (1.9)	43 (3.7)
Male	43 (1.9)	57 (3.7)
Other	0 (0.0)	0 (0.1)
Hispanic or Latino		
Yes	6 (0.8)	5 (1.3)
No	94 (0.8)	95 (1.3)
Race		
White	91 (1.2)	93 (1.4)
Asian	5 (0.9)	5 (1.2)
Black or African American	5 (0.9)	4 (1.1)
American Indian or Alaska Native	2 (0.5)	1 (0.5)
Native Hawaiian or Other Pacific Islander	0 (0.1)	1 (0.5)
Age		
≤ 30	14 (0.9)	16 (2.3)
31–40	31 (1.5)	32 (3.6)
41–50	28 (1.3)	26 (3.3)
51–60	20 (1.1)	19 (2.4)
61+	8 (0.9)	7 (1.6)
Experience Teaching Science at the K-12 Level		
0–2 years	15 (1.1)	17 (2.5)
3–5 years	13 (0.9)	13 (1.9)
6–10 years	17 (1.4)	16 (3.1)
11–20 years	35 (1.9)	34 (3.1)
≥ 21 years	20 (1.2)	20 (2.9)
Full-Time Job in Science Prior to Teaching		
Yes	36 (2.1)	36 (3.6)
No	64 (2.1)	64 (3.6)

The majority of physics teachers have one or two preparations—different subjects or levels (e.g., introductory/1st year chemistry, 2nd year physics), though nearly 40 percent have 3 or more preparations (see Table 2). These data are similar to those for biology and chemistry 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 physics teachers have had formal preparation for teaching leading to a teaching credential (see Table 3). Over 40 percent received their teaching credential as part of their undergraduate program, a quarter through a master's program, and almost another quarter via 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)

In terms of certification to teach specific science areas, teachers of high school physics are less likely to be certified to teach their subject than teachers of high school biology and chemistry. As can be seen in Table 4, 88 percent of biology teachers and 85 percent of chemistry teachers are certified in their subject area, compared to 75 percent of 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

Like high school teachers in general, 8 in 10 physics teachers have a college degree in science or engineering (see Table 5). Further, over half of physics teachers have a degree in science education.

Table 5
High School Science Teacher Degrees

	PERCENT OF TEACHERS	
	ALL SCIENCES	PHYSICS
Science/Engineering	79 (1.4)	80 (2.9)
Science Education	57 (2.1)	56 (4.5)
Science/Engineering or Science Education	91 (1.1)	92 (2.5)

However, the data show that physics teachers' science degrees are typically not in physics. Only 24 percent of physics teachers have a degree in physics, compared to 63 percent of biology teachers who have a biology degree and 42 percent of chemistry teachers with a chemistry degree (see Table 6). Further, over a third of physics teachers have taken no courses or only an introductory course in their subject compared to 10 percent or fewer of biology and chemistry teachers.

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 physics teachers. Ninety-six percent of physics teachers have taken an introductory physics course, and two-thirds have taken at least one advanced course in the topic. Over half have advanced coursework in mechanics, and 40–46 percent have coursework in electricity and magnetism, heat and thermodynamics, and modern or quantum physics. Nearly 4 in 10 have taken a physics teaching methods course.

Table 7
High School Physics Teachers Completing Various Physics College Courses

	PERCENT OF PHYSICS TEACHERS
Introductory Physics	96 (1.2)
One or More Physics Courses Beyond the Introductory Level	66 (3.6)
Mechanics	52 (3.8)
Electricity and Magnetism	46 (3.2)
Heat and Thermodynamics	40 (3.7)
Modern or Quantum Physics	40 (3.3)
Astronomy/Astrophysics	33 (3.2)
Optics	28 (3.9)
Nuclear Physics	17 (2.2)
Other physics beyond the general/introductory level	31 (3.5)
Physics Teaching Methods Course	39 (3.8)

The survey also asked physics teachers to rate how well prepared they feel to teach each of a number of fundamental topics in physics. A large majority of physics teachers feel very well prepared to teach about forces and motion, energy, and properties and behaviors of waves (see Table 8). Just under half feel very well prepared to teach electricity and magnetism, and fewer than a quarter feel very well prepared to teach modern physics. Few physics teachers feel not adequately prepared in any of these areas.

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

	PERCENT OF PHYSICS TEACHERS			
	NOT ADEQUATELY PREPARED	SOMEWHAT PREPARED	FAIRLY WELL PREPARED	VERY WELL PREPARED
Forces and motion	0 (0.3)	2 (0.9)	16 (3.7)	82 (3.7)
Energy transfers, transformations, and conservation	1 (0.5)	3 (1.1)	18 (3.7)	78 (3.8)
Properties and behaviors of waves	0 (0.3)	11 (3.3)	25 (3.2)	64 (3.8)
Electricity and magnetism	1 (0.3)	16 (3.4)	36 (4.4)	48 (4.6)
Modern physics (e.g., special relativity)	11 (2.2)	29 (3.2)	39 (4.3)	22 (2.7)

Data from items asking teachers how well prepared they feel to teach the content of a randomly selected class were combined into a composite variable called Perceptions of Content Preparedness. As can be seen in Table 9, physics teachers feel slightly less well prepared to teach physics than high school science teachers in general, as well as chemistry teachers, 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. Half or fewer feel at least fairly well prepared to teach students about defining engineering problems, developing possible solutions, or optimizing solutions (see Table 10). Only about 1 in 6 feel very well prepared in these areas.

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

	PERCENT OF PHYSICS TEACHERS			
	NOT ADEQUATELY PREPARED	SOMEWHAT PREPARED	FAIRLY WELL PREPARED	VERY WELL PREPARED
Developing possible solutions	20 (3.1)	29 (2.7)	33 (3.6)	18 (2.2)
Defining engineering problems	22 (3.1)	34 (3.1)	27 (2.9)	17 (2.2)
Optimizing a design solution	25 (3.3)	34 (3.3)	27 (3.6)	14 (2.2)

These items were combined into a composite variable titled Perceptions of Preparedness to Teach Engineering; scores are shown in Table 11. The composite scores show that physics teachers feel better prepared to teach engineering than high school science teachers in general, and biology and chemistry teachers specifically. This finding may be due to the relatively common and accessible connections between physics and engineering.

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 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 feel to use various student-centered pedagogies. Second, they were asked how well prepared they feel to carry out a number of tasks related to teaching in a specific science unit, including monitoring and addressing student understanding.

As can be seen in Table 12, the majority of physics teachers feel very well prepared to develop students' conceptual understanding and use formative assessment to monitor learning. One-third or fewer physics teachers feel very well prepared to differentiate instruction, provide instruction that is based on students' ideas, develop students' awareness of STEM careers, or incorporate students' cultural backgrounds into instruction.

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

	PERCENT OF TEACHERS	
	ALL SCIENCES	PHYSICS
Develop students' conceptual understanding	58 (1.5)	61 (3.5)
Use formative assessment to monitor student learning	52 (1.6)	53 (3.2)
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 (3.3)
Encourage students' interest in science and/or engineering	44 (1.6)	47 (3.4)
Encourage participation of all students in science and/or engineering	43 (1.6)	47 (3.2)
Differentiate science instruction to meet the needs of diverse learners	35 (1.5)	32 (2.7)
Provide science instruction that is based on students' ideas	25 (1.4)	27 (3.0)
Develop students' awareness of STEM careers	21 (1.2)	25 (2.3)
Incorporate students' cultural backgrounds into science instruction	18 (1.4)	19 (2.2)

Table 13 shows the percentage of classes taught by teachers who feel very well prepared to monitor and address student thinking. In the majority of high school physics classes, teachers feel very well prepared to assess student understanding at the end of a unit, monitor student understanding during instruction, implement designated instructional materials, and anticipate student difficulties.

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	PHYSICS
Assess student understanding at the conclusion of this unit	59 (1.8)	62 (4.3)
Monitor student understanding during this unit	53 (1.8)	59 (4.3)
Implement the instructional materials to be used during this unit	53 (1.6)	57 (4.0)
Anticipate difficulties that students may have with particular science ideas and procedures in this unit	45 (1.6)	52 (4.3)
Find out what students thought or already knew about the key science ideas	38 (1.6)	45 (4.5)

These two sets of items were combined into composite variables; scores are shown in Table 14. There are no differences on either composite among biology, chemistry, and physics teachers.

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

Teachers were asked about their beliefs regarding effective teaching and learning in science. As can be seen in Table 15, physics teachers hold a number of views that are in alignment with what is known about effective science instruction. For example, a large majority of physics teachers agree that: (1) teachers should ask students to support their conclusions with evidence, (2) students learn best when instruction is connected to their lives, and (3) students should learn science by doing science.

However, many physics teachers also hold views that are inconsistent with effective science instruction. About two-thirds of physics teachers believe that students should be provided with definitions for new vocabulary at the beginning of instruction on a science idea, and that students learn best in classes with students of similar abilities. In addition, although physics teachers are less likely than high school science teachers in general to think that hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned and that teachers should explain an idea to students before having them consider evidence that relates to the idea, a substantial portion agrees with each of these statements.

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

	PERCENT OF TEACHERS	
	ALL SCIENCES	PHYSICS
Reform-Oriented Beliefs		
Teachers should ask students to support their conclusions about a science concept with evidence.	99 (0.3)	98 (1.1)
Students learn best when instruction is connected to their everyday lives.	96 (0.7)	93 (2.0)
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)	90 (3.9)
Most class periods should provide opportunities for students to apply scientific ideas to real-world contexts.	91 (1.4)	84 (4.4)
Most class periods should provide opportunities for students to share their thinking and reasoning.	89 (1.4)	83 (4.4)
It is better for science instruction to focus on ideas in depth, even if that means covering fewer topics.	77 (2.0)	75 (3.6)
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)	66 (3.3)
Students learn science best in classes with students of similar abilities.	60 (1.7)	63 (3.8)
Hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned.	52 (2.0)	43 (3.8)
Teachers should explain an idea to students before having them consider evidence that relates to the idea.	37 (2.3)	24 (3.2)

† 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, and 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 educational background, preparedness, and beliefs, 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, about half of physics teachers have served on a school or district science committee in the last three years. About 4 in 10 have observed another other teacher's science lesson for the purpose of giving feedback or taught a lesson for other teachers to observe. Overall, the data are similar between physics teachers and all high school science teachers.

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

	PERCENT OF TEACHERS	
	ALL SCIENCES	PHYSICS
Served on a school or district/diocese-wide science committee	51 (2.0)	52 (4.9)
Observed another teacher's science lesson for the purpose of giving them feedback	50 (2.3)	43 (4.6)
Taught a science lesson for other teachers in their school to observe	38 (2.1)	41 (4.4)
Served as a lead teacher or department chair in science	33 (2.0)	36 (5.0)
Led or co-led a workshop or professional learning community for other teachers focused on science or science teaching	28 (1.7)	33 (4.8)
Served as a formal mentor or coach for a science teacher	27 (1.8)	24 (3.1)
Supervised a student teacher in their classroom	22 (2.3)	20 (3.6)

Professional Development of High School Physics Teachers

Science teachers, like all professionals, need opportunities to keep up with advances in their field, including both disciplinary content and how to help their students learn important science content. The 2018 NSSME+ collected data on teachers' participation in professional development, as well as characteristics of the professional development.

One 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, 85 percent of physics teachers have participated in science- or engineering-focused professional development (i.e., focused on science/engineering content or the teaching of science/engineering) in the last three years. Nearly 1 in 10 high school physics teacher have never participated in subject-specific professional development.

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

	PERCENT OF TEACHERS	
	ALL SCIENCES	PHYSICS
In the last 12 months	59 (1.8)	63 (3.0)
1–3 years ago	24 (1.5)	22 (2.7)
4–6 years ago	5 (0.8)	4 (0.9)
7–10 years ago	2 (0.4)	2 (0.8)
More than 10 years ago	2 (0.6)	2 (0.6)
Never	7 (0.9)	8 (2.2)

Further, physics teachers, like high school science teachers in general, have participated in little science- or engineering-focused professional development. Only about a third of physics teachers have spent 36 or more hours in professional development related to the discipline 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	PHYSICS
None	18 (1.3)	16 (2.5)
Less than 6 hours	8 (1.3)	7 (1.8)
6–15 hours	18 (1.6)	19 (3.6)
16–35 hours	22 (1.3)	20 (2.6)
36–80 hours	21 (1.4)	20 (2.3)
More than 80 hours	14 (1.0)	17 (2.1)

The most common form of professional development is the workshop, with 89 percent of physics teachers who have had professional development attending one in the previous three years (see Table 20). About half of physics 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	PHYSICS
Attended a professional development program/workshop	91 (1.5)	89 (2.9)
Participated in a professional learning community/lesson study/teacher study group	55 (1.7)	51 (4.6)
Attended a national, state, or regional science teacher association meeting	40 (2.0)	44 (5.0)
Completed an online course/webinar	34 (2.2)	35 (5.1)
Received assistance or feedback from a formally designated coach/mentor	35 (2.1)	31 (3.6)
Took a formal course for college credit	16 (1.4)	22 (3.2)

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

As can be seen in Table 21, about half of physics 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, or to engage in science investigations/engineering design challenges. About a third have had opportunities to examine classroom artifacts or rehearse instructional practices as part of their professional development.

[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.

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	PHYSICS
Worked closely with other teachers from their school	55 (2.3)	51 (4.0)
Worked closely with other teachers who taught the same grade and/or subject whether or not they were from their school	54 (2.1)	48 (5.0)
Had opportunities to engage in science investigations/engineering design challenges	45 (2.4)	48 (4.5)
Had opportunities to experience lessons, as their students would, from the textbook/ modules they use in their classroom	45 (2.4)	39 (3.4)
Had opportunities to apply what they learned to their classroom and then come back and talk about it as part of the professional development	43 (2.4)	39 (4.2)
Had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction)	39 (2.3)	37 (4.0)
Had opportunities to rehearse instructional practices during the professional development (i.e., try out, receive feedback, and reflect on those practices)	35 (2.3)	32 (3.5)

† 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 the professional growth opportunities teachers have had in the last three years. About half of physics teachers have had professional growth opportunities that gave heavy emphasis to deepening their understanding of how science is done (see Table 22). Monitoring student understanding during instruction; deepening their own science content knowledge; learning about difficulties students may have with ideas; differentiating instruction; and learning how to integrate engineering, mathematics, and/or computer science into their instruction were each a heavy focus of professional development for about 4 in 10 teachers. Relatively few physics teachers have had professional development with a heavy emphasis on deepening their understanding of how engineering is done or incorporating students' cultural backgrounds into 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	PHYSICS
Deepening your understanding of how science is done	51 (2.4)	54 (4.4)
Monitoring student understanding during science instruction	47 (2.0)	43 (4.1)
Deepening your own science content knowledge	45 (1.9)	43 (4.6)
Learning about difficulties that students may have with particular science ideas	40 (2.0)	39 (4.7)
Differentiating science instruction to meet the needs of diverse learners	46 (2.0)	38 (3.9)
Learning how to provide science instruction that integrates engineering, mathematics, and/or computer science	34 (2.1)	38 (4.3)
Finding out what students think or already know prior to instruction on a topic	37 (2.0)	31 (4.0)
Implementing the science textbook/module to be used in your classroom	29 (1.9)	30 (4.2)
Deepening your understanding of how engineering is done	23 (1.8)	26 (3.8)
Incorporating students' cultural backgrounds into science instruction	23 (2.1)	17 (2.7)

† 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 these two sets of items were combined into composite variables: one measuring the extent to which teachers' professional development experiences align with what is known about effective professional development, and one that measures the extent to which teachers' professional development supports student-centered instruction. As can be seen in Table 23, scores on both of these composite are 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 Physics Courses Offered

Of the high schools (schools including grades 9, 10, 11, or 12) in the United States, 82 percent offer at least one physics course, 60 percent offer a 1st year physics course, and 40 percent offer a 2nd year course (see Table 24). In regard to Advanced Placement (AP) physics, 31 percent of high schools offer AP Physics 1, and 13 percent offer AP Physics 2. There is a fairly large disparity between the percentage of high schools offering AP Physics and the percentage of high school students with access to the course, most likely due to the fact that large schools are more likely than small ones to offer advanced physics courses, and that small schools outnumber large schools in the United States. Very few schools offer the International Baccalaureate (IB) physics course.

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

	PERCENT OF HIGH SCHOOLS OFFERING	PERCENT OF HIGH SCHOOL STUDENTS WITH ACCESS
Any level	**82 (3.0)**	**94 (1.2)**
Non-college prep	**45 (3.4)**	**53 (2.4)**
1st year college prep, including honors	**60 (3.2)**	**78 (2.0)**
2nd year advanced	**40 (2.8)**	**67 (2.5)**
Any AP Physics	**41 (3.2)**	**63 (2.6)**
AP Physics 1	31 (2.9)	56 (2.6)
AP Physics 2	13 (1.7)	26 (2.8)
AP Physics C: Electricity and Magnetism	8 (1.2)	20 (2.3)
AP Physics C: Mechanics	12 (1.5)	24 (2.3)
IB Physics	**3 (0.7)**	**8 (1.6)**

In terms of the percentage of classes offered in the nation, physics (any level) accounts for 12 percent of all high school science classes (see Table 25). This percentage ranks third behind biology and chemistry.

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 physics class has approximately 19 students; two-thirds of the classes have between 11 and 28 students. Forty-one percent of 1st year physics students are female, which is less than the 51 percent in biology and chemistry (see Table 26). Further, although students from race/ethnicity groups historically underrepresented in STEM[7] make up about half of the student population, only 30 percent of students in 1st year physics 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.

Physics classes are more likely to be composed of high-prior-achieving students than other 1st year science classes, with 42 percent of class being classified by teachers this way (see Table 27). About a quarter of 1st year physics classes are composed of mostly average prior achievers, and another quarter consist of students with a mixture of prior achievement levels.

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 Physics Instruction

This section of the report draws on teachers' descriptions of what transpires in physics classrooms. It includes data on teachers' perceptions of autonomy for making decisions about the content and pedagogy of their classes, instructional objectives, and class activities.

Teachers' Perceptions of Their Decision-Making Autonomy

Teachers were asked the extent to which they had control over a number of curriculum and instruction decisions for their classes. Similar to other science classes, in physics classes teachers are likely to perceive themselves as having strong control over pedagogical decisions such as determining the amount of homework to be assigned and selecting teaching techniques (see Table 28). In fewer classes overall, teachers perceive themselves as having strong control in determining course goals and objectives, selecting curriculum materials (e.g., textbooks/ modules), and selecting what content/skills to teach.

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

	PERCENT OF CLASSES	
	ALL SCIENCES	PHYSICS
Determining the amount of homework to be assigned	74 (1.8)	76 (4.4)
Selecting teaching techniques	68 (2.3)	73 (4.4)
Selecting the sequence in which topics are covered	51 (2.1)	58 (4.2)
Choosing criteria for grading student performance	54 (2.2)	55 (5.7)
Determining amount of instructional time to spend on each topic	48 (2.1)	53 (4.2)
Determining course goals and objectives	36 (2.5)	44 (5.4)
Selecting curriculum materials (e.g., textbooks/modules)	36 (2.0)	43 (4.8)
Selecting content, topics, and skills to be taught	34 (2.2)	38 (5.3)

This pattern is evident in scores for two composite variables created from these items: Curriculum Control and Pedagogical Control. For both physics and non-physics classes, scores for the Pedagogical Control composite are substantially higher than for the Curriculum Control composite (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, physics classes are most likely to have a heavy emphasis on deepening students' conceptual understanding. About half of physics classes have a heavy emphasis on having students learn how to do science, and only about a third have a heavy emphasis on increasing student interest or learning about real-life applications.

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

	PERCENT OF CLASSES	
	ALL SCIENCES	PHYSICS
Understanding science concepts	76 (1.8)	85 (2.3)
Learning how to do science (develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)	41 (1.3)	51 (3.1)
Developing students' confidence that they can successfully pursue careers in science/engineering	35 (1.5)	41 (4.4)
Increasing students' interest in science/engineering	31 (1.5)	38 (3.4)
Learning about real-life applications of science/engineering	29 (1.2)	34 (3.0)
Learning test taking skills/strategies	23 (1.4)	17 (2.6)
Learning science vocabulary and/or facts	32 (1.6)	15 (2.4)
Learning how to do engineering (e.g., identify criteria and constraints, design solutions, optimize solutions)	5 (0.7)	14 (3.2)
Learning about different fields of science/engineering	7 (0.8)	5 (1.4)

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 higher in physics than high school science classes in general (see Table 31), indicating that physics classes are somewhat more likely to emphasize reform-oriented instructional objectives.

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 physics 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 physics classes include students working in small groups, the teacher explaining science ideas, and whole class discussions on a weekly basis. About three-quarters of physics 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 24 percent of physics classes have students write reflections on what they are learning. Overall, the data for physics classes are similar to those for high school science in general.

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

	PERCENT OF CLASSES	
	ALL SCIENCES	PHYSICS
Have students work in small groups	84 (1.5)	91 (2.2)
Explain science ideas to the whole class	92 (0.9)	90 (2.6)
Engage the whole class in discussions	78 (1.3)	78 (3.7)
Have students do hands-on/laboratory activities	68 (1.6)	77 (3.0)
Engage the class in project-based learning (PBL) activities	28 (1.7)	26 (3.4)
Have students write their reflections (e.g., in their journals, on exit tickets) in class or for homework	28 (1.4)	24 (3.5)
Focus on literacy skills (e.g., informational reading or writing strategies)	33 (1.6)	22 (3.8)
Have students read from a textbook, module, or other material in class, either aloud or to themselves	26 (1.7)	18 (3.4)
Use flipped instruction (have students watch lectures/demonstrations outside of class to prepare for in-class activities)	15 (1.3)	14 (2.9)
Have students practice for standardized tests	20 (1.5)	11 (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, developing models and explanations, and engaging in argumentation. As can be seen in Table 33, students in physics classes often engage in aspects of science related to conducting

[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.

investigations and analyzing data. For example, half or more of physics classes have students organize and represent data, conduct scientific investigations, analyze data, and make and support claims with evidence at least once a week. Further, students in physics are more likely to be engaged in most of these activities than high school science students in general.

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

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

	PERCENT OF CLASSES	
	ALL SCIENCES	PHYSICS
Organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data	58 (1.5)	70 (3.9)
Conduct a scientific investigation	50 (1.6)	67 (3.4)
Analyze data using grade-appropriate methods in order to identify patterns, trends, or relationships	47 (1.4)	58 (4.0)
Select and use grade-appropriate mathematical and/or statistical techniques to analyze data	30 (1.6)	55 (4.0)
Make and support claims with evidence	50 (1.5)	54 (4.2)
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)	50 (4.0)
Develop scientific models—physical, graphical, or mathematical representations of real-world phenomena	34 (1.5)	50 (4.7)
Use mathematical and/or computational models to generate data to support a scientific claim	26 (1.3)	49 (3.7)
Determine what data would need to be collected in order to answer a scientific question	39 (1.4)	43 (3.2)
Develop procedures for a scientific investigation to answer a scientific question	32 (1.4)	40 (3.2)
Generate scientific questions	38 (1.8)	35 (3.0)
Consider how missing data or measurement error can affect the interpretation of data	27 (1.5)	35 (4.7)
Revise their explanations based on additional evidence	28 (1.4)	30 (3.2)
Summarize patterns, similarities, and differences in scientific information obtained from multiple sources	28 (1.5)	30 (3.3)
Use multiple sources of evidence to develop an explanation	33 (1.6)	29 (3.7)
Use data and reasoning to defend, verbally or in writing, a claim or refute alternative scientific claims	27 (1.7)	26 (4.0)
Determine whether or not a question is scientific	28 (1.5)	25 (3.8)
Identify the strengths and limitations of a scientific model—in terms of accuracy, clarity, generalizability, accessibility to others, strength of evidence supporting it	22 (1.1)	23 (3.2)
Evaluate the strengths and weaknesses of competing scientific explanations	20 (1.6)	22 (3.4)
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 (2.9)
Pose questions that elicit relevant details about the important aspects of a scientific argument	23 (1.6)	20 (2.9)
Determine what details about an investigation might persuade a targeted audience about a scientific claim	17 (1.3)	15 (3.5)
Construct a persuasive case, verbally or in writing, for the best scientific model or explanation for a real-world phenomenon	15 (1.1)	14 (2.6)

These items were combined into a composite variable titled Engaging Students in the Practices of Science. The scores on this composite indicate that students, in physics and high school science in general, engage in this set of practices, on average, just once or twice a month or less (see Table 34).

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, physics classes are more likely than high school science classes in general to experience engineering, with over half of physics classes engaging in engineering at least once a month. Fewer than 1 in 5 physics classes incorporate coding at all during the school year.

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

	PERCENT OF CLASSES	
	ALL SCIENCES	PHYSICS
Engineering		
Never	20 (1.8)	6 (1.7)
Rarely (e.g., a few times per year)	50 (1.9)	40 (3.8)
Sometimes (e.g., once or twice a month)	24 (1.5)	35 (4.6)
Often (e.g., once or twice a week)	6 (1.1)	17 (3.0)
All or almost all science lessons	1 (0.2)	3 (1.1)
Coding		
Never	89 (1.2)	82 (3.6)
Rarely (e.g., a few times per year)	6 (0.9)	14 (3.1)
Sometimes (e.g., once or twice a month)	4 (0.8)	4 (1.4)
Often (e.g., once or twice a week)	0 (0.1)	0 (0.3)
All or almost all science lessons	0 (0.0)	0 (0.3)

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. Over 80 percent of physics classes include students working in small groups and the teacher explaining a science idea to the whole class in the most recent lesson (see Table 36). Whole class discussion and students completing textbook/worksheet problems occur in about half of physics lessons. The teacher conducting a demonstration is more common in physics classes than high school science classes in general (49 vs. 31 percent, respectively), and students reading or writing about science is less common (16 vs. 29 percent and 23 vs. 34 percent, respectively).

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

	PERCENT OF CLASSES	
	ALL SCIENCES	PHYSICS
Students working in small groups	81 (1.4)	84 (3.0)
Teacher explaining a science idea to the whole class	81 (1.3)	81 (2.7)
Whole class discussion	59 (1.6)	55 (3.5)
Students completing textbook/worksheet problems	44 (1.6)	51 (4.0)
Teacher conducting a demonstration while students watched	31 (1.6)	49 (3.4)
Students doing hands-on/laboratory activities	40 (1.6)	41 (3.6)
Students writing about science	34 (1.8)	23 (3.3)
Test or quiz	16 (1.2)	17 (3.1)
Students reading about science	29 (1.6)	16 (3.5)
Practicing for standardized tests	8 (0.9)	6 (1.4)

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. On average, there is little difference between physics and high school classes overall (see Table 37). Approximately 40 percent of class time is spent on whole class activities, 35 percent on small group work, and 20 percent on students working individually. Non-instructional activities, including attendance taking and interruptions, account for 10 percent or less 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	PHYSICS
Whole class activities (e.g., lectures, explanations, discussions)	38 (0.8)	38 (1.4)
Small group work	34 (0.8)	37 (2.0)
Students working individually (e.g., reading textbooks, completing worksheets, taking a test or quiz)	19 (0.8)	16 (1.7)
Non-instructional activities (e.g., attendance taking, interruptions)	10 (0.2)	9 (0.4)

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 physics classes assign between 31 and 90 minutes of homework per week. Overall, the data for physics are similar to high school science in general.

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

	PERCENT OF CLASSES	
	ALL SCIENCES	PHYSICS
None	3 (0.5)	6 (2.1)
1–15 minutes per week	9 (1.3)	3 (1.4)
16–30 minutes per week	19 (1.3)	16 (3.2)
31–60 minutes per week	33 (1.6)	29 (4.5)
61–90 minutes per week	22 (1.9)	26 (4.1)
91–120 minutes per week	7 (0.9)	9 (1.8)
More than 2 hours per week	7 (0.9)	9 (2.3)

The survey asked how often students in the randomly selected class were required to take assessments the teachers did not develop, such as state or district benchmark assessments. Nearly 40 percent of physics classes are not required to take any such assessments, and a third are required to take an external assessment once a year (see Table 39).

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

	PERCENT OF CLASSES	
	ALL SCIENCES	PHYSICS
Never	31 (2.0)	39 (4.7)
Once a year	33 (2.0)	32 (6.8)
Twice a year	14 (1.7)	11 (2.6)
Three or four times a year	16 (1.5)	11 (2.6)
Five or more times a year	6 (0.9)	7 (2.6)

Resources Available for High School Physics

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. Just over half of physics classes are expected to use instructional materials designated by the school or district (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)
Physics	56 (3.7)

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 physics, like high school science in general, the textbook still dominates, with the most commonly designated materials being commercially published textbooks (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	PHYSICS
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	95 (0.9)	88 (3.5)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	25 (2.0)	31 (4.0)
State, county, district, or diocese-developed units or lessons	27 (1.7)	29 (4.7)
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)	16 (1.5)	20 (3.1)
Commercially published kits/modules (printed or electronic)	22 (2.0)	17 (3.4)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)	11 (1.8)	7 (2.5)

† 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 is based on various types of materials. As can be seen in Table 42, teacher-created units or lessons are very likely to be used on a weekly basis in 91 percent of physics classes, which is even greater than the 86 percent of high school science classes overall. Units or lessons teachers collect from any other source and commercially published textbooks are the next most common, though much less frequently the basis for instruction, 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	PHYSICS
Units or lessons you created (either by yourself or with others)	86 (1.0)	91 (2.0)
Units or lessons you collected from any other source (e.g., conferences, journals, colleagues, university or museum partners)	49 (1.7)	48 (3.7)
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	50 (1.7)	47 (3.5)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	31 (1.8)	34 (3.9)
Commercially published kits/modules (printed or electronic)	21 (1.5)	14 (2.4)
State, county, district, or diocese-developed units or lessons	14 (1.2)	13 (1.9)
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)	11 (2.3)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)	9 (1.0)	7 (1.7)

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. The most commonly used physics materials are:

- *Conceptual Physics* (Pearson);
- *Physics* (Houghton Mifflin Harcourt);
- *Physics—Principles and Problems* (McGraw-Hill);
- *Physics: Principles with Applications* (Pearson); and
- *Physics* (Wiley).

Table 43 shows the publication year of commercially published instructional materials used. Forty-four percent of high school physics classes use commercially published materials published prior to 2010.

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

	PERCENT OF CLASSES†	
	ALL SCIENCES	PHYSICS
2009 or earlier	43 (2.1)	44 (4.4)
2010–12	27 (1.9)	12 (2.9)
2013–15	20 (1.8)	34 (3.7)
2016–18	9 (1.4)	9 (2.2)

† 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 more than half of high school physics classes were 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)
Physics	52 (4.5)

† 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, the materials heavily influence physics instruction. Teachers in nearly 70 percent of physics classes use the textbook substantially to guide the overall structure and content emphasis of their units. Second, it is clear that teachers modify their materials substantially when designing instruction. In 50–69 percent of physics classes, teachers incorporate activities from other sources substantially, “pick and choose” from the material, and modify activities from the materials.

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

	PERCENT OF CLASSES‡	
	ALL SCIENCES	PHYSICS
I modified activities from these materials.	71 (2.7)	70 (5.0)
I incorporated activities (e.g., problems, investigations, readings) from other sources to supplement what these materials were lacking.	78 (2.1)	69 (7.7)
I used these materials to guide the structure and content emphasis of the unit.	76 (2.0)	69 (5.5)
I picked what is important from these materials and skipped the rest.	53 (2.6)	50 (7.0)

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

Teachers were asked why they skip parts of their textbook/module. As can be seen in Table 46, teachers in the vast majority of these physics classes skip activities because they have other ones that work better. Other common reasons for skipping activities include a lack of instructional time, the ideas not being in teachers' pacing guides/standards, students already knowing the ideas, the activities being too difficult, and not having the materials to implement the activity.

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

	PERCENT OF CLASSES†	
	ALL SCIENCES	PHYSICS
I have different activities for those science ideas that work better than the ones I skipped.	77 (4.0)	84 (5.2)
I did not have enough instructional time for the activities I skipped.	74 (3.5)	75 (6.4)
The science ideas addressed in the activities I skipped are not included in my pacing guide/standards.	73 (3.2)	57 (7.8)
My students already knew the science ideas or were able to learn them without the activities I skipped.	52 (3.5)	55 (8.6)
The activities I skipped were too difficult for my students.	59 (3.4)	54 (8.7)
I did not have the materials needed to implement the activities I skipped.	54 (3.7)	50 (8.3)
I did not have the knowledge needed to implement the activities I skipped.	20 (2.6)	22 (5.7)

† 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.

Given that teachers often skip activities in their materials because they know of better ones, it is perhaps not surprising that many supplement their materials. Providing students with additional practice is the reason for supplementing in nearly 9 in 10 physics classes (see Table 47). Many supplement with additional activities favored by the teacher or to help students at different levels of achievement learn targeted ideas.

Table 47
Reasons Why High School Science Materials Are Supplemented

	PERCENT OF CLASSES†	
	ALL SCIENCES	PHYSICS
Supplemental activities were needed to provide students with additional practice.	86 (3.7)	87 (4.3)
I had additional activities that I liked.	88 (2.6)	84 (5.0)
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)	76 (5.5)
Supplemental activities were needed to prepare students for standardized tests.	53 (3.6)	46 (8.6)
My pacing guide indicated that I should use supplemental activities.	46 (3.3)	43 (9.0)

† 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, they rated each of several factors that may have contributed to their decision (see Table 48). Not having enough time to implement the activities as designed was given as a reason in 62 percent of physics classes. In about half of physics classes, teachers cited that the original activities are too difficult or too easy for students, or not having the necessary materials or supplies.

Table 48
Reasons Why High School Science Materials Are Modified

	PERCENT OF CLASSES†	
	ALL SCIENCES	PHYSICS
I did not have enough instructional time to implement the activities as designed.	71 (2.8)	62 (7.3)
The original activities were too difficult conceptually for my students.	58 (3.3)	49 (9.1)
I did not have the necessary materials/supplies for the original activities.	53 (3.4)	49 (8.0)
The original activities were too easy conceptually for my students.	44 (3.6)	48 (8.6)
The original activities were too structured for my students.	38 (3.1)	41 (9.0)
The original activities were not structured enough for my students.	40 (3.5)	34 (10.5)

† 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 Physics Instructional Resources

Teachers were presented with a list of instructional resources and asked about their availability (either always in the classroom or upon request) in the randomly selected class. As can be seen in Table 49, high school physics classes are similar to high school science classes in general in terms of access to these resources. All physics classes have access to balances, and the vast majority have access to projection devices, microscopes, and probes for data collection.

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

	PERCENT OF CLASSES	
	ALL SCIENCES	PHYSICS
Balances (e.g., pan, triple beam, digital scale)	97 (0.8)	100 (0.4)
Projection devices (e.g., Smartboard, document camera, LCD projector)	98 (0.8)	94 (4.1)
Microscopes	94 (1.0)	90 (2.3)
Probes for collecting data (e.g., motion sensors, temperature probes)	81 (2.3)	86 (4.4)

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

Teachers were also asked about the availability, either in their classroom or in another room, of laboratory facilities. In nearly all physics classes, teachers have access to electric outlets, lab tables, and running water (see Table 50).

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

	PERCENT OF CLASSES	
	ALL SCIENCES	PHYSICS
Electric outlets	98 (0.6)	99 (0.8)
Lab tables	95 (0.9)	94 (1.9)
Faucets and sinks	94 (1.1)	91 (2.4)
Fume hoods	85 (1.7)	76 (4.4)
Gas for burners	82 (1.8)	74 (4.6)

† 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 the majority of high school physics classes consider their instructional technology, access to consumable supplies and equipment, and facilities adequate (see Table 51). On a composite variable created from these items titled Adequacy of Resources for Instruction, physics classes have a similar mean score to high school science classes overall (see Table 52).

Table 51
Adequacy† of Resources for High School Science Instruction

	PERCENT OF CLASSES	
	ALL SCIENCES	PHYSICS
Instructional technology (e.g., calculators, computers, probes/sensors)	70 (2.1)	77 (4.6)
Equipment (e.g., thermometers, magnifying glasses, microscopes, beakers, photogate timers, Bunsen burners)	73 (1.9)	73 (4.4)
Facilities (e.g., lab tables, electric outlets, faucets and sinks)	72 (2.0)	73 (5.0)
Consumable supplies (e.g., chemicals, living organisms, batteries)	67 (2.1)	69 (4.4)

† 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 Physics 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. The survey included items asking teachers about the extent various factors promote or inhibit instruction in their randomly selected class.

As can be seen in Table 53, in the majority of physics classes, teachers think that many factors promote effective instruction, including principal support; students' motivation, interest, and effort; time for teachers to plan; and students' prior knowledge and skills. Teacher evaluation, textbook selection, and state/district testing/accountability policies are seen as promoting effective instruction in a minority of physics classes.

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

	PERCENT OF CLASSES	
	ALL SCIENCES	PHYSICS
Principal support	66 (1.9)	72 (4.3)
Students' motivation, interest, and effort in science	60 (1.9)	70 (3.8)
Amount of time for you to plan, individually and with colleagues	69 (2.2)	68 (3.9)
Students' prior knowledge and skills	59 (2.2)	65 (3.7)
College entrance requirements	53 (2.1)	57 (5.1)
Amount of time available for your professional development	52 (2.2)	52 (4.9)
Current state standards	55 (2.2)	51 (5.5)
Parent/guardian expectations and involvement	43 (2.6)	49 (5.4)
Pacing guides	48 (2.3)	43 (5.5)
Teacher evaluation policies	42 (2.3)	36 (4.7)
Textbook/module selection policies	38 (2.5)	32 (5.4)
State/district/diocese testing/accountability policies‡	29 (1.8)	25 (5.4)

† 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. Overall, these data indicate that the climate is generally supportive for physics instruction specifically and high school science more generally.

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, nearly all high school physics teachers are white; unlike high school teachers in general, the majority of physics teachers are male. In terms of teaching experience, physics teachers reflect the high school teacher population; about a third are in their first five years of teaching science, and a fifth have more than 20 years of experience. Physics teachers are much less likely to have a degree in physics than biology or chemistry teachers. Fewer than a quarter have a degree in physics, and more than a third have not taken any college courses in physics beyond the introductory level. Thus it is not surprising that physics teachers feel less well prepared to teach physics than high school science teachers in general do to teach their subject. However, although physics teachers are more likely than other high school science teachers to feel prepared to incorporate engineering into their instruction, many do not feel well prepared to do so.

In terms of pedagogical preparedness, physics teachers are similar to high school science teachers more broadly. The majority feel very well prepared to develop students' conceptual understanding and 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 physics teachers' beliefs about effective teaching show a dichotomy. On the one hand, a large majority hold a number of beliefs about teaching and learning that are in alignment 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 holds views inconsistent with this research. For example, two-thirds of physics teachers believe that students should be provided with definitions for new vocabulary at the beginning of instruction on an idea.

When asked about their professional development experiences, a large majority of high school physics teachers have participated 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 physics teachers attending professional development indicated that it had a heavy focus on deepening their understanding of how science is done, and for about 4 in 10, professional development has had heavy emphasis on monitoring student understanding and deepening their science content knowledge.

Data on physics courses indicate that nearly all students in the nation have access to one or more physics courses at their schools, though fewer than two-thirds have access to an AP physics course. In addition, female students are less likely than male students to take a 1st year physics course (they are equally likely to take 1st year biology or chemistry course). Further, despite constituting about half of the student population, students from race/ethnicity groups historically underrepresented make up only about a third of the enrollment in 1st year college prep science courses including physics.

Data on instruction indicate that physics instruction relies heavily on lecture and discussion, though students are engaged in hands-on/laboratory activities fairly regularly. In addition, students in physics classes are more likely than students in high school science more generally to be engaged in engineering activities. In terms of engagement with the practices of sciences, students in physics 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 physics classes base instruction on teacher-developed lessons on a weekly basis; fewer than half of physics 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 physics classes have access to needed laboratory facilities, and the large majority of physics teachers think their access to technology, equipment, and consumable supplies is adequate.