NSSME | THE NATIONAL SURVEY OF SCIENCE & MATHEMATICS EDUCATION

Obstacles to and Progress Toward the Vision of the NGSS

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horizon RESEARCH, INC.

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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

A Brief History of NGSS Development and Adoption

The Next Generation Science Standards (NGSS)[1] are the United States' foremost K–12 science education policy document. The standards describe a vision of science instruction in which disciplinary core ideas, crosscutting concepts, and science practices are interwoven. Their release in 2013 and subsequent adoption culminated years of work, summarized briefly here.

In July 2011, the National Research Council published the Framework for K–12 Science Education,[2] followed by a two-year effort—coordinated by Achieve—to develop the NGSS. Twenty-six "lead state partners" collaborated in the effort. In April 2013, Achieve released the NGSS for adoption, and in 2013 and 2014, 15 states and the District of Columbia adopted either the NGSS or NGSS-like standards.[3] Throughout this report, we refer to these states as early adopters. From 2015 to 2018, 24 additional states followed suit (and are referred to as late adopters). By 2018, adopting states accounted for approximately two-thirds of the nation's students. Finally, 11 states had adopted neither the NGSS nor NGSS-like standards in 2018 and are referred to as non-adopters in this report. Figure 1 shows the states by adoption status as of August 2018.[4] Among other things, the map demonstrates that not all lead state partners ultimately adopted the NGSS.

Adoption of NGSS or NGSS-Like Standards—August 2018

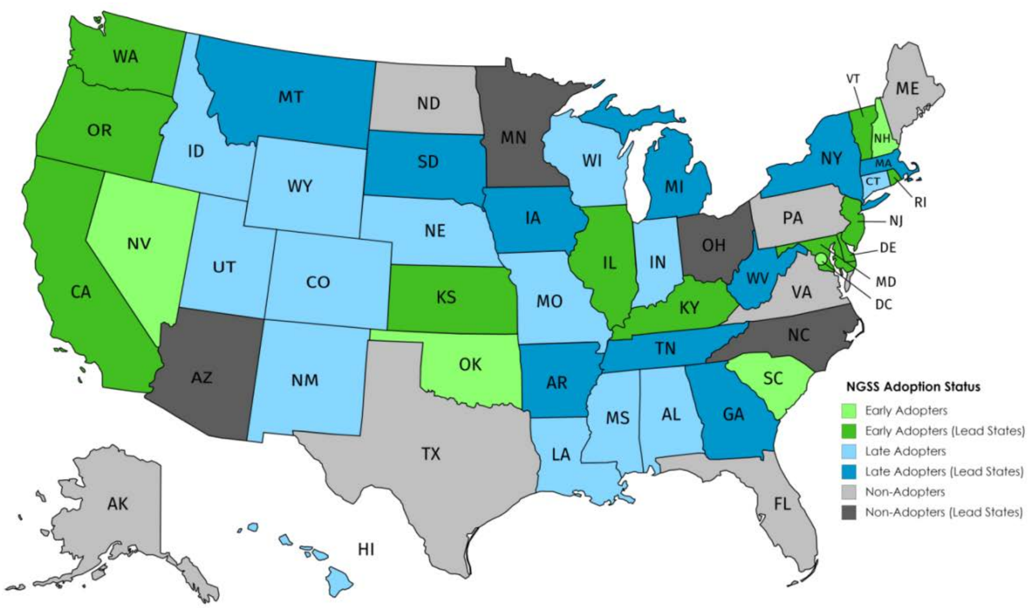


Figure 1

[1] NGSS Lead States. (2013). *Next generation science standards: For states, by states.* The National Academies Press.

[2] National Research Council. (2012). *A framework for K-12 science education: Practices, crosscutting concepts, and core ideas*. National Academies Press.

[3] National Science Teaching Association. (n.d.). *About the Next Generation Science Standards*. Retrieved July 25, 2018, from https://www.verse.com/video/732-next-generation-science-standards-explained-by-david-evans-of-national-science-teachers-association/

[4] Additional states have adopted the NGSS or NGSS-like standards since August 2018.

NGSS and the NSSME+

This report discusses results from the 2018 iteration of the National Survey of Science and Mathematics Education[5] (NSSME+[6]), a major study of K–12 schools and science teachers in the US. The 2018 NSSME+ was the sixth in a series of studies dating back to 1977[7] and the only survey focused exclusively on STEM education that provides nationally representative results. Though not intentional, its immediate predecessor (the 2012 NSSME) was a snapshot of science instruction in the U.S. just before release of the NGSS. In this sense, the 2012 study provides baseline data. The 2018 NSSME+, following five years after release of the NGSS, generated a wealth of data that can be used to take stock of obstacles to and progress toward the vision of the NGSS. Figure 2 shows the relationship between: (1) NGSS development and adoption and (2) the NSSME.

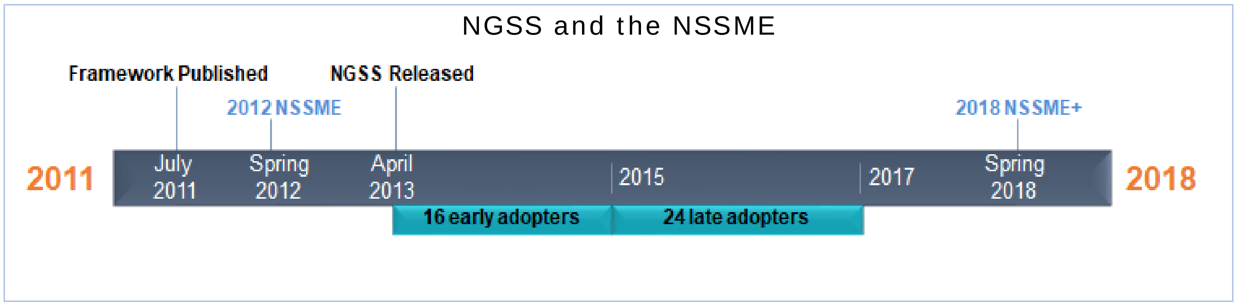


Figure 2

The 2018 NSSME+ study, like its predecessors, is based on survey data from a national probability sample of approximately 10,000 computer science, mathematics, and science teachers in grades K–12 in public and private schools in the 50 states and the District of Columbia. The study was conducted during the 2017–18 school year with a sample designed to allow for nationally representative estimates of computer science, mathematics, and science education indicators, including teacher background and instructional practices. The study employed a two-stage sample design. First, a random sample of schools, stratified by region of the country, community type, and grades served was selected. Second, a stratified random sample of teachers within schools that agreed to participate was drawn. This design resulted in a sample that is nationally representative and has a sufficient number of cases of various subgroups (e.g., race/ethnicity groups, SES) to allow the data to be disaggregated.

Teachers in self-contained classrooms, most of them elementary teachers, were randomly assigned to either science or mathematics and received a subject-specific questionnaire. In-depth data about curriculum and instruction in a single class were obtained from each teacher (for non-self-contained teachers, a single class was randomly selected for the basis of these questions). Data for this report come from the Science Teacher Questionnaire and the Science Program Questionnaire, the latter completed by a program representative (e.g., department chair or lead teacher). These instruments were based on previously used surveys, with new items developed and validated by expert review and cognitive interviewing. Data collection concluded in July

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

[6] The plus symbol denotes the study's emphasis on computer science instruction, in addition to mathematics and science.

[7] Other iterations of the study took place in 1977, 1985, 1993, 2000, and 2012.

2018. The final response rates for school program questionnaires and teacher questionnaires were 82 percent and 78 percent, respectively.

After data collection, design weights were computed, adjusted for nonresponse, and applied to the data. The sampling and weighting processes result in nationally representative estimates of schools, teachers, and classes. Results in this report include standard errors that indicate the certainty of each estimate.

Looking for Obstacles and Progress

Classroom instruction is an obvious place to look for influence of the NGSS, but instruction occurs in a complex system of influences, including teachers themselves, professional development, state standards, and instructional materials. Of course, many other factors influence instruction, but these categories are the ones for which the 2018 NSSME+ provides data. It is also important to point out that the NGSS are but one of these factors. Even in adopting states, influence of the NGSS may be muted by other factors. In addition, given the complexity and inertia of the U.S. education system, it is not clear that five years is enough time to see evidence of impact from NGSS adoption.

This report starts with science instruction, considering the national status in 2018, differences by NGSS-adoption status, and, where possible, changes from 2012 to 2018. The remainder of the report presents data on each of the factors identified above in an attempt to explain the differences, or lack thereof, in instruction.

Science Instruction

The 2018 NSSME+ collected data on instructional objectives, classroom practices, and engagement of students with science practices. And while surveys are excellent for measuring quantities—how often things happen, what resources are in schools, etc.—they are not as well suited for measuring quality. However, research on learning suggests that excellent science instruction is characterized by certain practices. A school or teacher may implement a desirable practice poorly, but if survey data indicate that the practice is absent altogether, instruction is unlikely to be effective. The results that follow address the presence of factors related to instruction but not the quality with which they are present.

Instructional Objectives

The survey provided a list of possible objectives of instruction and asked teachers how much emphasis each would receive in an entire course of a particular, randomly selected class. Table 1 shows the percentage of science classes by grade range giving each objective heavy emphasis. Understanding science concepts was the most frequently emphasized objective, although more so in secondary science classes (about three-quarters of middle and high school classes) than in elementary (fewer than half of classes). Given the widespread adoption of the NGSS or NGSS-like standards, it is somewhat surprising that fewer than half of secondary classes, and only a quarter of elementary classes, had a heavy emphasis on students learning how to do science. Objectives least likely to be emphasized were learning about different fields of science and engineering and learning how to do engineering (10 percent or fewer of science classes). In fact, 18–31 percent of science classes, depending on grade range, had no emphasis on learning how to do engineering (see Table 2), which is surprising given the emphasis the NGSS place on engineering.

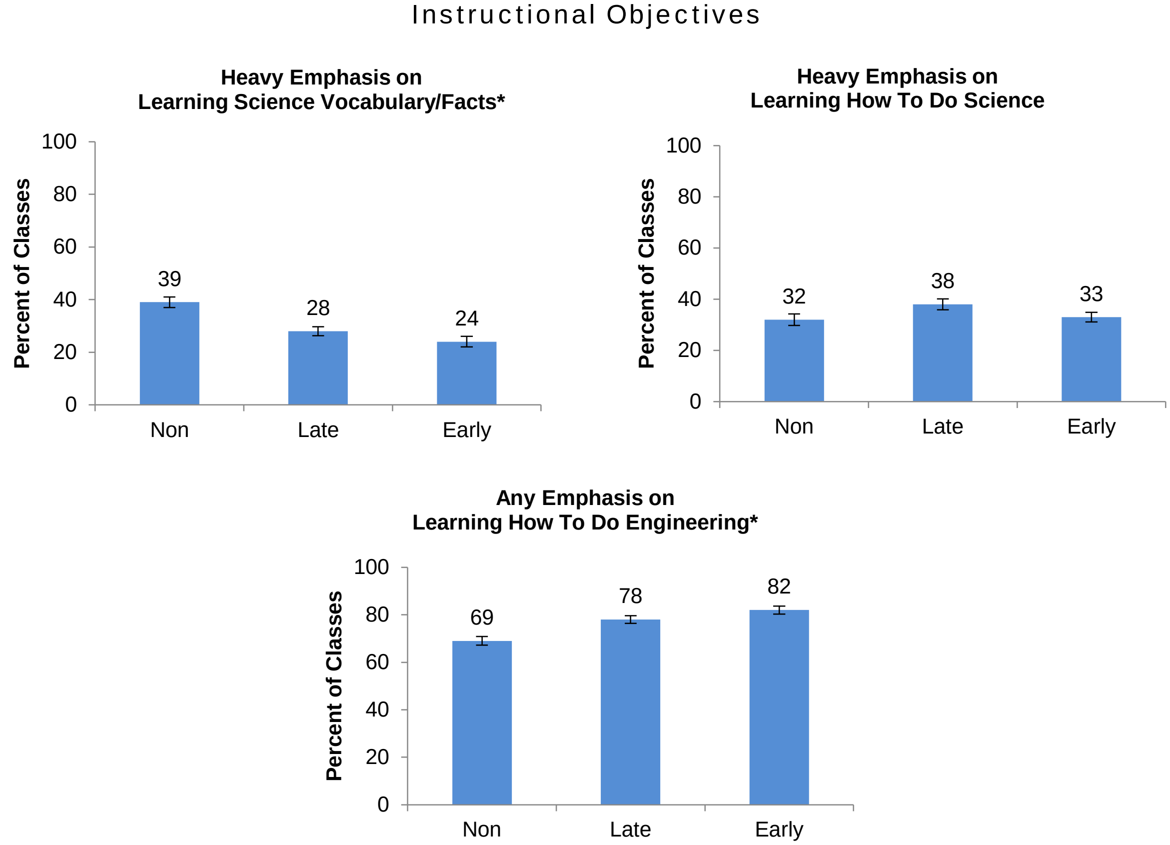
Table 1
Science Classes With Heavy Emphasis on
Various Instructional Objectives, by Grade Range

	PERCENT OF CLASSES		
	ELEMENTARY	MIDDLE	HIGH
Understanding science concepts	47 (1.7)	77 (1.8)	76 (1.8)
Learning how to do science (develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)	26 (2.0)	46 (2.1)	41 (1.3)
Developing students' confidence that they can successfully pursue careers in science/engineering	23 (2.0)	30 (1.9)	35 (1.5)
Learning science vocabulary and/or facts	27 (1.9)	37 (2.2)	32 (1.6)
Increasing students' interest in science/engineering	27 (2.2)	35 (2.1)	31 (1.5)
Learning about real-life applications of science/engineering	20 (2.1)	28 (2.0)	29 (1.2)
Learning test-taking skills/strategies	20 (1.5)	23 (1.8)	23 (1.4)
Learning about different fields of science/engineering	8 (1.9)	7 (1.2)	7 (0.8)
Learning how to do engineering (e.g., identify criteria and constraints, design solutions, optimize solutions)	8 (1.8)	10 (1.2)	5 (0.7)

Table 2
Science Classes With No Emphasis on Learning How To Do Engineering

	PERCENT OF CLASSES
Elementary	22 (1.6)
Middle	18 (1.9)
High	31 (1.5)

As can be seen in Figure 3, two differences by NGSS-adoption status are apparent: (1) classes in adopting states were less likely than those in non-adopting states to focus on students learning vocabulary/facts, and (2) they were more likely to place any emphasis on engineering. Both differences suggest some progress toward the NGSS vision. Somewhat surprising is that there is no difference by adoption status in classes placing heavy emphasis on learning to do science.



* There is a statistically significant difference between classes in non- and late-adopting states and between classes in non- and early adopting states (two-tailed independent samples t-tests, $p < 0.05$).

Figure 3

Classroom Practices

Elementary teachers in self-contained classrooms were asked how often they teach mathematics and/or science. As can be seen in Table 3, mathematics was taught in virtually all classes on most or all school days in grades K–3 and 4–6. In contrast, science was taught less frequently, with only 17 percent of grades K–3 classes and 35 percent of grades 4–6 classes receiving science instruction all or most days, every week of the school year (see Table 4). Many elementary classes received science instruction only a few days a week or during some weeks of the year. None of these data have changed since 2012. However, as shown in Figure 4, in 2018, self-contained classes in adopting states were even less likely than those in non-adopting states to receive science instruction all or most days.

Table 3
Frequency With Which Self-Contained Elementary Teachers Teach Mathematics†

	PERCENT OF CLASSES	
	2012	2018
Grades K–3		
All/Most days, every week	99 (0.4)	99 (0.2)
Three or fewer days, every week	1 (0.3)	1 (0.2)
Some weeks, but not every week	1 (0.3)	0 (0.1)
Grades 4–6		
All/Most days, every week	98 (0.9)	99 (0.4)
Three or fewer days, every week	2 (0.9)	1 (0.4)
Some weeks, but not every week	0 ---[a]	0 ---[a]

† There are no significant differences in the distributions of responses between classes in 2012 and classes in 2018 (Chi-square test of independence, $p \geq 0.05$).

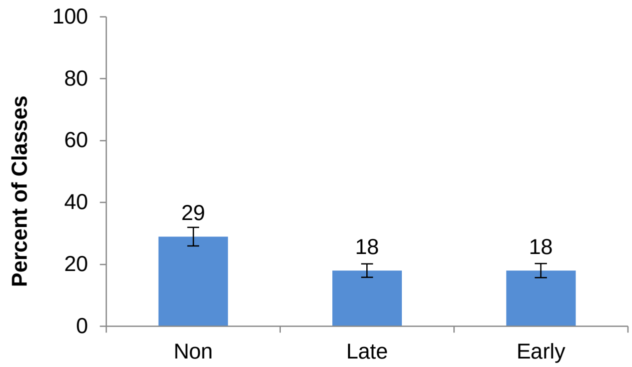
a No grades 4–6 teachers in the sample selected this response option. Thus, it is not possible to calculate the standard error of this estimate.

Table 4
Frequency With Which Self-Contained Elementary Teachers Teach Science†

	PERCENT OF CLASSES	
	2012	2018
Grades K–3		
All/Most days, every week	20 (1.5)	17 (1.5)
Three or fewer days, every week	39 (1.5)	40 (1.8)
Some weeks, but not every week	41 (1.9)	43 (2.0)
Grades 4–6		
All/Most days, every week	35 (2.6)	35 (3.1)
Three or fewer days, every week	33 (2.6)	36 (3.1)
Some weeks, but not every week	32 (2.5)	29 (2.4)

† There are no significant differences in the distributions of responses between classes in 2012 and classes in 2018 (Chi-square test of independence, $p \geq 0.05$).

Self-Contained Elementary Classes in Which Students Receive Science Instruction All or Most Days (2018)*



* There is a statistically significant difference between classes in non- and late-adopting states and between classes in non- and early adopting states (two-tailed independent samples t-tests, $p < 0.05$).

Figure 4

The survey also asked about the approximate number of minutes typically spent teaching mathematics, science, social studies, and reading/language arts in self-contained classes. The average number of minutes per day typically spent on instruction in each subject in grades K–3 and 4–6 is shown in Table 5. To facilitate comparisons among the subject areas, only teachers who taught all four of these subjects to one class of students (i.e., teachers of self-contained classes) were included in this analysis. In 2018, grades K–3 self-contained classes spent an average of 89 minutes per day on reading/language arts instruction and 57 minutes on mathematics instruction, compared to only 18 minutes on science. The pattern in grades 4–6 is similar, with 82 minutes per day devoted to reading/language arts, 63 minutes to mathematics, and 27 minutes to science instruction (a slight increase over 2012). Regarding minutes of science instruction in K–6 self-contained classes, there was no difference by adoption status (see Figure 5).

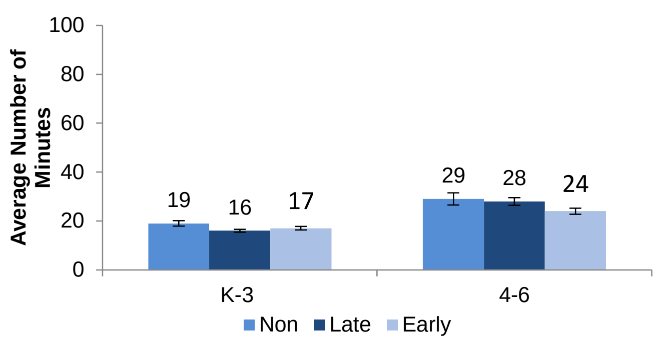
Table 5
Average Number of Minutes Per Day Spent
Teaching Each Subject in Self-Contained Classes,[a] by Grade Range

	NUMBER OF MINUTES	
	2012	2018
Grades K–3		
Reading/Language Arts	89 (1.7)	89 (1.7)
Mathematics*	54 (1.0)	57 (0.8)
Science	19 (0.5)	18 (0.5)
Social Studies	16 (0.4)	16 (0.4)
Grades 4–6		
Reading/Language Arts	83 (2.2)	82 (2.4)
Mathematics	61 (1.4)	63 (1.6)
Science*	24 (0.9)	27 (0.8)
Social Studies	21 (0.8)	21 (0.8)

* There is a statistically significant difference between classes in 2012 and classes 2018 (two-tailed independent samples t-test, $p < 0.05$).

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

Self-Contained Minutes of
Science Instruction (2018)[†]



† There is not a statistically significant difference between classes in different adoption states (two-tailed independent samples t-tests, $p \geq 0.05$).

Figure 5

Instructional Activities

Teachers responded to several items about their instruction in a randomly selected science class. One of these asked how often teachers used different pedagogies (e.g., explaining ideas to students, small group work). Another asked how often they engaged students in aspects of the science practices. Response options for both sets of items were never, rarely (e.g., a few times a year), sometimes (e.g., once or twice a month), often (e.g., once or twice a week), and all or almost all science lessons. As can be seen in Table 6, three instructional activities occurred at least once a week in a large majority of science classes across grade levels: explaining science ideas to the whole class (85–92 percent), engaging the whole class in discussions (78–90 percent), and having students work in small groups (75–87 percent). Just over half of elementary and about two-thirds of secondary science classes included hands-on/laboratory activities on a weekly basis. In addition, roughly 30 percent of classes engaged students in project-based learning activities weekly. There were very few substantive differences between 2012 and 2018. However, one common across grades is a reduction in students reading during class.

Table 6
Science Classes in Which Teachers Report
Using Various Activities at Least Once a Week

	PERCENT OF CLASSES	
	2012	2018
Elementary		
Engage the whole class in discussions	90 (0.9)	90 (1.0)
Explain science ideas to the whole class	88 (1.3)	85 (1.9)
Have students work in small groups	72 (1.8)	75 (1.6)
Focus on literacy skills (e.g., informational reading or writing strategies)*	48 (2.0)	60 (1.6)
Have students do hands-on/laboratory activities	55 (1.9)	53 (1.9)
Have students write their reflections (e.g., in their journals, on exit tickets) in class or for homework	44 (2.0)	43 (2.0)
Have students read from a textbook, module, or other material in class, either aloud or to themselves*	48 (2.4)	37 (1.7)
Engage the class in project-based learning (PBL) activities	30 (1.7)	29 (2.2)
Have students practice for standardized tests	19 (1.7)	17 (1.3)
Middle		
Engage the whole class in discussions	92 (1.0)	89 (1.2)
Explain science ideas to the whole class*	96 (0.9)	92 (1.0)
Have students work in small groups*	79 (1.9)	87 (1.5)
Focus on literacy skills (e.g., informational reading or writing strategies)	44 (2.2)	46 (2.3)
Have students do hands-on/laboratory activities	62 (2.4)	63 (2.0)
Have students write their reflections (e.g., in their journals, on exit tickets) in class or for homework	44 (2.1)	47 (2.1)
Have students read from a textbook, module, or other material in class, either aloud or to themselves*	56 (2.3)	39 (2.6)
Engage the class in project-based learning (PBL) activities*	23 (1.9)	31 (2.3)
Have students practice for standardized tests	23 (1.9)	19 (1.7)
High		
Engage the whole class in discussions*	83 (1.0)	78 (1.3)
Explain science ideas to the whole class*	95 (0.8)	92 (0.9)
Have students work in small groups	83 (1.2)	84 (1.5)
Focus on literacy skills (e.g., informational reading or writing strategies)*	25 (1.5)	33 (1.6)
Have students do hands-on/laboratory activities	70 (1.5)	68 (1.6)
Have students write their reflections (e.g., in their journals, on exit tickets) in class or for homework*	21 (1.3)	28 (1.4)
Have students read from a textbook, module, or other material in class, either aloud or to themselves*	37 (1.6)	26 (1.7)
Engage the class in project-based learning (PBL) activities*	18 (1.2)	28 (1.7)
Have students practice for standardized tests	20 (1.2)	20 (1.5)

* There is a statistically significant difference between classes in 2012 and classes in 2018 (two-tailed independent samples t-test, $p < 0.05$).

Only three of the activities in Table 6 are different by adoption status (see Figure 6). Classes in early adopting states were slightly less likely to have the teacher explain ideas and slightly more likely to have students do hands-on activities. Classes in both early and late-adopting states were more likely to engage students in project-bases learning (PBL) activities, but the frequency is low regardless of adoption status.

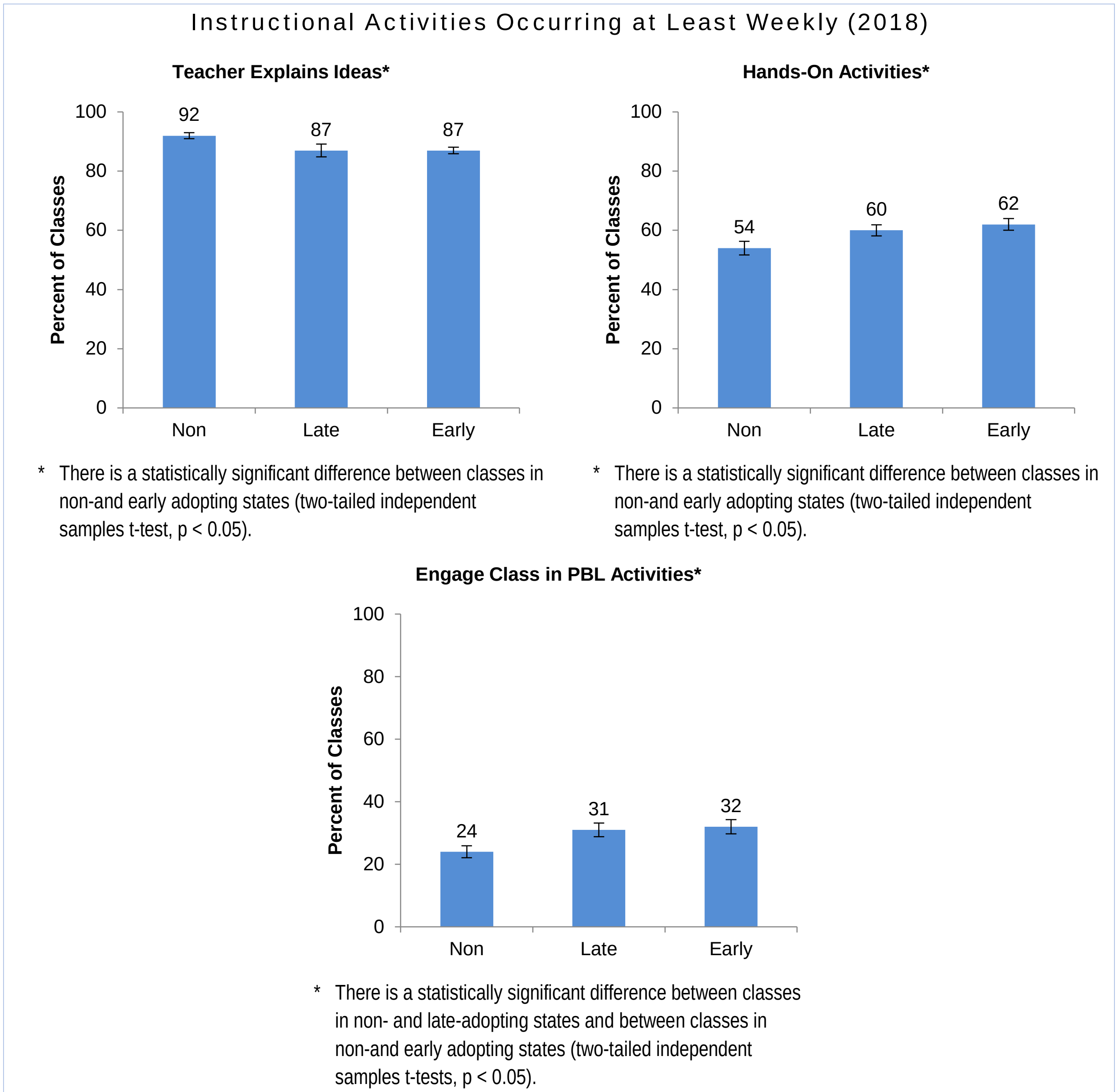
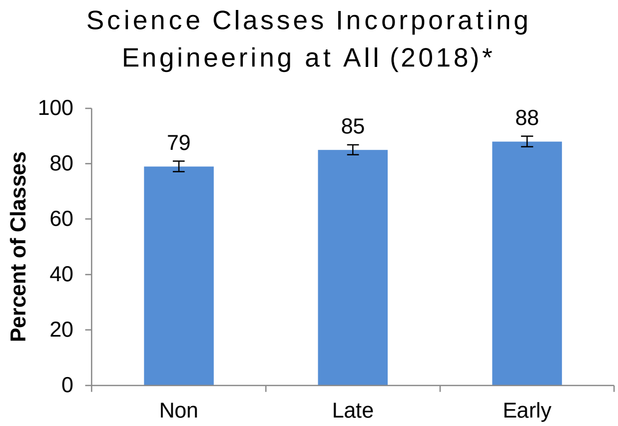


Figure 6

As mentioned previously, the NGSS place considerable emphasis on incorporating engineering into science instruction. This practice was uncommon across grade ranges (see Table 7). However, classes in early and late-adopting states were more likely to incorporate engineering at all (see Figure 7).

Table 7
Science Classes in Which Teachers Report
Incorporating Engineering Into Science Instruction, by Grade Range

	PERCENT OF CLASSES		
	ELEMENTARY	MIDDLE	HIGH
Never	16 (1.8)	10 (1.8)	20 (1.8)
Rarely (e.g., a few times per year)	48 (2.5)	51 (2.4)	50 (1.9)
Sometimes (e.g., once or twice a month)	26 (2.2)	32 (2.2)	24 (1.5)
Often (e.g., once or twice a week)	8 (2.7)	5 (1.0)	6 (1.1)
All or almost all science lessons	1 (0.5)	1 (0.6)	1 (0.2)



* There is a statistically significant difference between classes in non- and late-adopting states and between classes in non-and early adopting states (two-tailed independent samples t-tests, $p < 0.05$).

Figure 7

Of particularly interest from an NGSS-implementation perspective, 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 (hereafter referred to as the Framework)—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 8, students often engaged in aspects of science related to conducting investigations and analyzing data. For example, about half of middle and high school classes had students organize and represent data, make and support claims with evidence, conduct scientific investigations, and analyze data at least once a week. At the elementary level, about a third of classes engaged students in these activities weekly.

Across all grade bands, students tended not to 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 secondary science classes had students do each of the following 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. Even fewer elementary classes engaged students in these activities weekly, and about a third never did (see Table 9).

Table 8
Science Classes in Which Teachers Report Students Engaging in Various Aspects of Science Practices at Least Once a Week, by Grade Range

	PERCENT OF CLASSES		
	ELEMENTARY	MIDDLE	HIGH
Organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data	34 (2.1)	49 (2.3)	58 (1.5)
Make and support claims with evidence	32 (2.0)	51 (2.1)	50 (1.5)
Conduct a scientific investigation	36 (2.2)	48 (2.2)	50 (1.6)
Analyze data using grade-appropriate methods in order to identify patterns, trends, or relationships	27 (1.9)	43 (2.4)	47 (1.4)
Determine what data would need to be collected in order to answer a scientific question	29 (2.1)	39 (2.1)	39 (1.4)
Generate scientific questions	38 (2.2)	44 (2.2)	38 (1.8)
Compare data from multiple trials or across student groups for consistency in order to identify potential sources of error or inconsistencies in the data	19 (2.2)	31 (2.3)	36 (1.5)
Develop scientific models—physical, graphical, or mathematical representations of real-world phenomena	19 (1.7)	34 (2.3)	34 (1.5)
Use multiple sources of evidence to develop an explanation	26 (2.0)	37 (2.3)	33 (1.6)
Develop procedures for a scientific investigation to answer a scientific question	29 (2.2)	35 (2.1)	32 (1.4)
Select and use grade-appropriate mathematical and/or statistical techniques to analyze data	15 (1.4)	21 (1.8)	30 (1.6)
Determine whether or not a question is scientific	19 (1.6)	31 (1.8)	28 (1.5)
Revise their explanations based on additional evidence	22 (2.0)	30 (2.1)	28 (1.4)
Summarize patterns, similarities, and differences in scientific information obtained from multiple sources	18 (2.2)	25 (2.0)	28 (1.5)
Use data and reasoning to defend, verbally or in writing, a claim or refute alternative scientific claims	17 (1.6)	28 (1.8)	27 (1.7)
Consider how missing data or measurement error can affect the interpretation of data	14 (1.5)	21 (2.1)	27 (1.5)
Use mathematical and/or computational models to generate data to support a scientific claim	12 (1.2)	19 (1.4)	26 (1.3)
Pose questions that elicit relevant details about the important aspects of a scientific argument	14 (1.4)	24 (1.8)	23 (1.6)
Evaluate the credibility of scientific information—e.g., its reliability, validity, consistency, logical coherence, lack of bias, or methodological strengths and weaknesses	8 (1.1)	19 (1.7)	23 (1.4)
Identify the strengths and limitations of a scientific model—in terms of accuracy, clarity, generalizability, accessibility to others, strength of evidence supporting it	12 (1.8)	22 (2.0)	22 (1.1)
Evaluate the strengths and weaknesses of competing scientific explanations	12 (1.3)	19 (1.7)	20 (1.6)
Determine what details about an investigation might persuade a targeted audience about a scientific claim	11 (1.2)	15 (1.6)	17 (1.3)
Construct a persuasive case, verbally or in writing, for the best scientific model or explanation for a real-world phenomenon	10 (1.1)	17 (1.5)	15 (1.1)

Table 9
Science Classes in Which Teachers Report Students Never Engaging in Various Aspects of Science Practices, by Grade Range

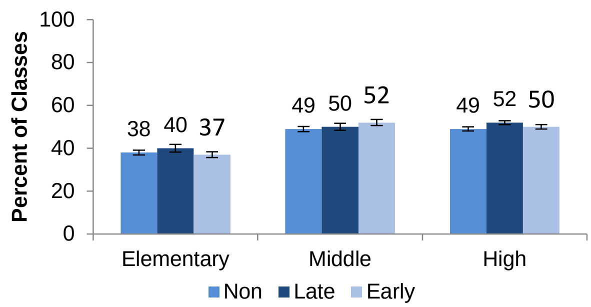
	PERCENT OF CLASSES		
	ELEMENTARY	MIDDLE	HIGH
Organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data	6 (0.7)	1 (0.3)	1 (0.3)
Make and support claims with evidence	10 (1.1)	1 (0.3)	2 (0.5)
Conduct a scientific investigation	4 (0.6)	2 (0.6)	2 (0.4)
Analyze data using grade-appropriate methods in order to identify patterns, trends, or relationships	12 (1.1)	3 (1.0)	3 (0.6)
Determine what data would need to be collected in order to answer a scientific question	8 (0.9)	2 (0.5)	3 (0.5)
Generate scientific questions	6 (0.8)	2 (0.4)	3 (0.5)
Compare data from multiple trials or across student groups for consistency in order to identify potential sources of error or inconsistencies in the data	22 (1.4)	4 (0.8)	4 (0.6)
Develop scientific models—physical, graphical, or mathematical representations of real-world phenomena	19 (1.1)	3 (0.6)	5 (0.7)
Use multiple sources of evidence to develop an explanation	15 (1.2)	3 (0.6)	5 (0.6)
Develop procedures for a scientific investigation to answer a scientific question	9 (1.0)	3 (0.6)	4 (0.8)
Select and use grade-appropriate mathematical and/or statistical techniques to analyze data	27 (1.5)	12 (1.6)	8 (0.9)
Determine whether or not a question is scientific	20 (1.4)	5 (0.8)	8 (0.7)
Revise their explanations based on additional evidence	17 (1.2)	4 (0.7)	5 (0.8)
Summarize patterns, similarities, and differences in scientific information obtained from multiple sources	24 (1.2)	9 (1.5)	10 (1.1)
Use data and reasoning to defend, verbally or in writing, a claim or refute alternative scientific claims	27 (1.5)	8 (1.6)	9 (0.8)
Consider how missing data or measurement error can affect the interpretation of data	24 (1.5)	4 (1.0)	4 (0.7)
Use mathematical and/or computational models to generate data to support a scientific claim	28 (1.6)	10 (1.5)	9 (1.0)
Pose questions that elicit relevant details about the important aspects of a scientific argument	31 (1.4)	12 (1.5)	13 (1.3)
Evaluate the credibility of scientific information—e.g., its reliability, validity, consistency, logical coherence, lack of bias, or methodological strengths and weaknesses	38 (1.6)	13 (1.5)	11 (0.9)
Identify the strengths and limitations of a scientific model—in terms of accuracy, clarity, generalizability, accessibility to others, strength of evidence supporting it	31 (1.4)	8 (1.3)	6 (0.9)
Evaluate the strengths and weaknesses of competing scientific explanations	33 (1.4)	10 (1.5)	11 (1.2)
Determine what details about an investigation might persuade a targeted audience about a scientific claim	33 (1.7)	15 (1.8)	16 (1.3)
Construct a persuasive case, verbally or in writing, for the best scientific model or explanation for a real-world phenomenon	35 (1.6)	16 (1.7)	17 (1.4)

These items were combined into a composite variable[8] titled Engaging Students in the Practices of Science. The scores on this composite indicate that students were more likely to be engaged in doing science in middle and high school classes than they were in elementary classes (see Table 10). In addition, the scores indicate that students engaged in this set of practices, on average, just once or twice a month or less. There was no difference in the composite mean by adoption status (see Figure 8).

Table 10
Science Class Mean Scores for Engaging Students in the Practices of Science Composite

	MEAN SCORE
Elementary	39 (0.8)
Middle	50 (0.8)
High	50 (0.6)

Science Class Mean Scores for Engaging Students in the Practices of Science Composite, by Grade Band and Adoption Status†



† There is not a statistically significant difference between classes in different adoption states (two-tailed independent samples t-tests, $p \geq 0.05$).

Figure 8

To summarize, despite widespread adoption of the NGSS or NGSS-like standards, instructional time for science at the elementary level is still quite low. Generally, the data point to only a few differences in instruction by adoption status. Perhaps the most discouraging is that elementary science instruction was less frequent in adopting states than in non-adopting states. However, when science was taught, regardless of grade level, classes in adopting states were more likely to emphasize learning how to do engineering, and they were less likely to emphasize learning vocabulary and facts. In terms of instructional activities, classes in early adopting states were

[8] Composite variables have the advantage of being more reliable than individual items. Each composite was calculated by summing the responses to the relevant items and then dividing by the total points possible. Composite scores can range from 0 to 100 points; someone who marks the lowest point on every item in a composite receives a score of 0, and someone who marks the highest point on every item receives a score of 100. NOTE: Some composite variables were computed differently in 2012 and 2018. To allow for comparisons across time, these were recomputed using only items common to both time points. Composite definitions are included in the Appendix.

less likely to have the teacher explain ideas and more likely to have students do hands-on activities. Overall, the data suggest that much work lies ahead to achieve the vision laid out in the Framework and the standards themselves. The sections that follow present data on other aspects of the science education system, highlighting areas of progress and areas where more work is needed.

Characteristics of the Science Teaching Force

The 2018 NSSME+ included items about several aspects of the science teaching force, including their beliefs, their preparation (courses completed and degrees), and their perceptions of preparedness.

Teacher Beliefs

Teachers were asked about their beliefs regarding effective teaching and learning in science. Table 11 shows the percentage of science teachers in each grade range agreeing with each of the statements. It is interesting to note that elementary, middle, and high school science teachers have similar views about a number of elements of science instruction, many of which align closely with the NGSS. At least 90 percent of teachers in each grade range agreed 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 apply scientific ideas to real-world contexts. A similarly large proportion of science teachers in each grade range believe that most class periods should provide opportunities for students to share their thinking and reasoning.

At the same time, substantial proportions of teachers hold views that are inconsistent with the NGSS. For example, roughly one-third of science teachers at each grade range agreed that teachers should explain an idea to students before having them consider evidence for that idea, and more than half agree that laboratory activities should be used primarily to reinforce ideas that students have already learned. And despite recommendations that students develop understanding of concepts first and learn the scientific language later, 66–77 percent of science teachers at the various grade ranges thought that students should be given definitions for new vocabulary at the beginning of instruction on a science idea.

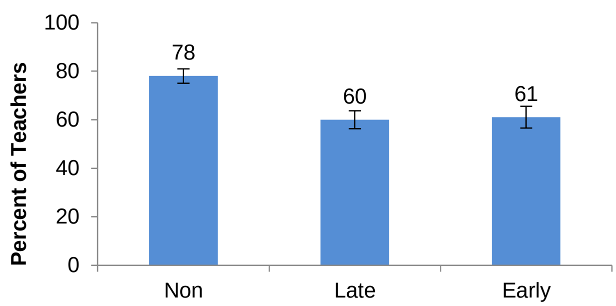
Table 11
Science Teachers Agreeing† With Various Statements About Teaching and Learning, by Grade Range

	PERCENT OF TEACHERS		
	ELEMENTARY	MIDDLE	HIGH
Reform-Oriented Beliefs			
Teachers should ask students to support their conclusions about a science concept with evidence.	95 (1.1)	97 (0.9)	99 (0.3)
Students learn best when instruction is connected to their everyday lives.	95 (1.0)	97 (0.7)	96 (0.7)
Students should learn science by doing science (e.g., developing scientific questions; designing and conducting investigations; analyzing data; developing models, explanations, and scientific arguments).	95 (1.0)	93 (1.7)	93 (1.2)
Most class periods should provide opportunities for students to apply scientific ideas to real-world contexts.	93 (1.2)	90 (2.0)	91 (1.4)
Most class periods should provide opportunities for students to share their thinking and reasoning.	96 (0.9)	92 (1.9)	89 (1.4)
It is better for science instruction to focus on ideas in depth, even if that means covering fewer topics.	75 (2.1)	74 (2.9)	77 (2.0)
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.	77 (2.1)	72 (2.3)	66 (2.1)
Students learn science best in classes with students of similar abilities.	25 (1.9)	48 (3.6)	60 (1.7)
Hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned.	56 (2.4)	57 (2.6)	52 (2.0)
Teachers should explain an idea to students before having them consider evidence that relates to the idea.	33 (2.1)	30 (2.6)	37 (2.3)

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

For the most part, teacher beliefs do not vary by state adoption status. One exception is high school teachers’ beliefs about introducing vocabulary at the start of instruction. Teachers in adopting states were considerably less likely to agree that teachers should employ this practice (see Figure 9).

High School Teachers Agreeing That Vocabulary Should be Introduced at the Beginning of Instruction (2018)*



* There is a statistically significant difference between teachers in non- and late-adopting states and between teachers in non-and early adopting states (two-tailed independent samples t-tests, $p < 0.05$).

Figure 9

These items in Table 11 were combined into two composite variables: Traditional Teaching Beliefs and Reform-Oriented Teaching Beliefs. The composite scores shown in Table 12 suggest that elementary, middle, and high school science teachers have relatively strong reform-oriented beliefs. However, traditional beliefs were also fairly prevalent across all grades, and there were no differences by NGSS-adoption status.

Table 12
Mean Scores for Science Teachers' Beliefs About Teaching and Learning Composites

	MEAN SCORE	
	TRADITIONAL BELIEFS	REFORM-ORIENTED BELIEFS
Elementary	55 (0.9)	86 (0.6)
Middle	57 (1.1)	87 (0.7)
High	59 (0.7)	85 (0.5)

Teacher Preparation

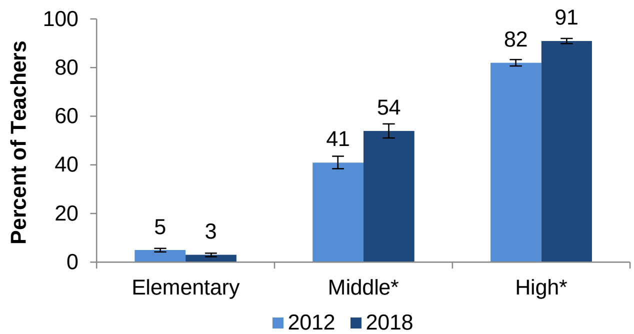
To help students learn, teachers must themselves have a firm grasp of important ideas in the discipline they are teaching, and the NGSS place even greater demands on teachers' content knowledge than former national standards. Because direct measures of content knowledge were not feasible in this study, the survey used a number of proxy measures, including teachers' major areas of study and courses completed.

As can be seen in Table 13, very few elementary teachers had college or graduate degrees in science, engineering, or science education. The percentage of teachers with such degrees increases with increasing grade range to 91 percent of high school science teachers. Further, among both middle and high school science teachers, the percentage has increased since 2012 (see Figure 10).

Table 13
Science Teacher Degrees, by Grade Range

	PERCENT OF TEACHERS		
	ELEMENTARY	MIDDLE	HIGH
Science/Engineering	3 (0.5)	42 (2.2)	79 (1.4)
Science Education	1 (0.3)	36 (2.8)	57 (2.1)
Science/Engineering or Science Education	3 (0.7)	54 (2.9)	91 (1.1)

Degree in Science,
Engineering, or Science Education*



* There is a statistically significant difference between 2012 and 2018 for middle and high school science teachers (two-tailed independent samples t-test, $p < 0.05$).

Figure 10

Teachers of science in the elementary grades are typically responsible for instruction across science disciplines. Accordingly, the National Science Teachers Association (NSTA) has recommended that rather than studying a single science discipline in depth, elementary science teachers be prepared to teach life science, Earth science, and physical science.[9] As a proxy for the competencies outlined by NSTA in these different areas, teachers were asked about their coursework in each. As can be seen in Table 14, only 34 percent of elementary science teachers have had at least a single course in all three of those areas, and another 37 percent have had coursework in 2 of the 3 areas. At the other end of the spectrum, 7 percent of elementary science teachers have not had any college science courses in these areas. There were no meaningful differences by NGSS-adoption status or over time.

Table 14
Elementary Science Teachers' Coursework Related to NSTA Preparation Standards[†]

	PERCENT OF TEACHERS	
	2012	2018
Courses in Earth, life, and physical science[a]	36 (1.6)	34 (1.5)
Courses in 2 of the 3 areas	39 (1.8)	37 (1.6)
Course in 1 of the 3 areas	21 (1.4)	23 (1.4)
Courses in 0 of the 3 areas	5 (0.9)	7 (1.0)

† There is no significant difference in the distribution of responses between teachers in 2012 and those in 2018 (chi-square test of independence, $p \geq 0.05$).

a Physical science is defined as a course in either chemistry or physics.

Forty-seven percent of middle grades teachers of general or integrated science have had at least one college course in chemistry, Earth science, life science, and physics. An additional 30

9 National Science Teachers Association. (2012). NSTA science content analysis form: Elementary science specialists or middle school science teachers. Arlington, VA: NSTA.

percent have had coursework in 3 of the 4 areas (see Table 15). Again, there were no meaningful differences by NGSS-adoption status or over time.

Table 15
Middle School Teachers of General/Integrated
Science Coursework Related to NSTA Preparation Standards

	PERCENT OF TEACHERS*	
	2012	2018
Courses in chemistry, Earth science, life science, and physics	44 (2.6)	47 (2.6)
Courses in 3 of the 4 areas	27 (2.6)	30 (3.0)
Courses in 2 of the 4 areas	22 (2.2)	13 (1.9)
Course in 1 of the 4 areas	5 (1.0)	4 (0.9)
Courses in 0 of the 4 areas	1 (1.0)	7 (2.4)

* There is a statistically significant difference in the distribution of respondents between teachers in 2012 and those in 2018 (Chi-square test of independence, $p < 0.05$).

Many secondary science classes, especially at the high school level, focus on a single area of science, such as biology or chemistry. Table 16 shows the percentage of secondary science teachers with a degree in the courses they taught, both in 2012 and 2018. The percentage of middle school life science/biology teachers with a degree in the subject increased from 27 to 40 percent between 2012 and 2018. At the high school level, both life science/biology and chemistry teachers were more likely to have a degree in their subject in 2018. The increase among chemistry teachers is particularly striking.

Table 16
Secondary Science Teachers With a Degree in Field[a]

	PERCENT OF TEACHERS	
	2012	2018
Middle		
Life science/biology*	27 (4.0)	40 (4.5)
Physical science	9 (3.9)	7 (3.3)
Earth science	10 (2.8)	5 (1.3)
High		
Life science/biology*	54 (2.4)	63 (2.5)
Chemistry*	25 (1.8)	42 (2.7)
Physics	20 (2.3)	24 (2.6)
Earth science	15 (2.9)	15 (2.9)
Environmental science	9 (2.9)	11 (3.4)

* There is a statistically significant difference between teachers in 2012 and teachers in 2018 (two-tailed independent samples t-test, $p < 0.05$).

[a] Teachers assigned to teach classes in more than one subject area are included in each category.

Teachers' Perceptions of Preparedness

Although elementary teachers are typically assigned to teach multiple subjects to a single group of students, as can be seen in Table 17, these teachers do not feel equally well prepared to teach the various subjects. Almost three-fourths of elementary teachers of self-contained classes feel very well prepared to teach mathematics, but only 31 percent feel very well prepared to teach science. Further, the percentage of elementary teachers who feel very well prepared to teach science declined from 39 percent in 2012 to 31 percent in 2018. This finding did not vary by NGSS-adoption status and suggests a growing obstacle to implementation. It is even possible that the NGSS are contributing to the decline as teachers grapple with the new standards, what some refer to as an "implementation dip."[10]

Table 17
Elementary Teachers Feeling
Very Well Prepared to Teach Each Subject

	PERCENT OF TEACHERS[a]	
	2012	2018
Reading/Language Arts*	81 (1.0)	77 (1.2)
Mathematics	77 (1.7)	73 (1.6)
Social studies*	47 (1.5)	42 (1.3)
Science*	39 (2.1)	31 (1.9)

* There is a statistically significant difference between teachers in 2012 and teachers in 2018 (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes only teachers assigned to teach multiple subjects to a single class of students in grades K–6.

Focusing on science specifically, no more than a quarter of elementary teachers felt very well prepared to teach the individual disciplines of life, Earth/space, and physical science (see Table 18). In addition, each of these percentages declined between 2012 and 2018, again suggesting a formidable obstacle to NGSS implementation at the elementary level. Somewhat encouraging is the large drop in the percentage of teachers who did not feel adequately prepared to teach engineering (see Table 19).

Table 18
Elementary Teachers Feeling
Very Well Prepared to Teach Various Science Disciplines

	PERCENT OF TEACHERS	
	2012	2018
Life science*	29 (1.6)	24 (1.5)
Earth/Space science*	26 (1.4)	20 (1.5)
Physical science*	17 (1.2)	13 (1.1)
Engineering	4 (0.6)	3 (0.6)

* There is a statistically significant difference between teachers in 2012 and teachers in 2018 (two-tailed independent samples t-test, $p < 0.05$).

[10] Fullan, M. (2007). *The New Meaning of Educational Change* (4th edition). Teachers College Press.

Table 19
Elementary Teachers Feeling Not Adequately Prepared to Teach Various Science Disciplines

	PERCENT OF TEACHERS	
	2012	2018
Life science/biology	4 (0.6)	3 (0.7)
Earth/Space science*	4 (0.6)	6 (0.8)
Physical science	8 (1.0)	11 (1.3)
Engineering*	73 (1.7)	51 (2.2)

* There is a statistically significant difference between teachers in 2012 and teachers in 2018 (two-tailed independent samples t-test, $p < 0.05$).

The teacher questionnaires included a series of items about a single, randomly selected science class in the respondent's schedule. Middle and high school science teachers were shown a list of topics based on the subject of that class and asked how well prepared they felt to teach each of those topics at the grade levels they teach. As can be seen in Table 20, middle school teachers' feelings of preparedness have changed little since 2012. The two exceptions in the percentage feeling very well prepared are both decreases—regarding Earth's features and physical processes (from 51 to 42 percent) and climate and weather (from 42 to 31 percent). The latter is particularly discouraging given the importance of students developing an understanding of climate change.

Table 20
Middle School Science Teachers Considering Themselves Very Well Prepared to Teach Each of a Number of Topics

	PERCENT OF TEACHERS[a]	
	2012	2018
Earth/Space Science		
Earth's features and physical processes*	51 (2.9)	42 (2.2)
The solar system and the universe	36 (2.6)	32 (2.0)
Climate and weather*	42 (3.0)	31 (2.3)
Biology/Life Science		
Structures and functions of organisms	52 (3.1)	55 (2.7)
Ecology/ecosystems	48 (2.6)	52 (3.0)
Cell biology	49 (2.6)	50 (2.6)
Genetics	41 (2.5)	46 (3.0)
Evolution	33 (2.5)	40 (2.8)
Chemistry		
States, classes, and properties of matter	58 (2.5)	55 (2.6)
The periodic table	49 (2.3)	47 (3.0)
Atomic structure	45 (2.4)	46 (3.2)
Elements, compounds, and mixtures	53 (2.6)	45 (2.6)
Properties of solutions	33 (2.3)	30 (2.2)
Chemical bonding, equations, nomenclature, and reactions	31 (2.0)	28 (2.6)
Physics		
Forces and motion	42 (2.7)	44 (3.5)
Energy transfers, transformations, and conservation	37 (2.6)	39 (3.0)
Properties and behaviors of waves	23 (2.5)	21 (2.1)
Electricity and magnetism	23 (2.5)	19 (2.0)
Modern physics	5 (1.3)	7 (1.3)
Environmental and Resource Issues (e.g., land and water use, energy resources and consumption, sources and impacts of pollution)	35 (3.0)	31 (2.8)

* There is a statistically significant difference between teachers in 2012 and teachers in 2018 (two-tailed independent samples t-test, $p < 0.05$).

[a] Each middle school science teacher was asked about one set of science topics based on the discipline of their randomly selected class.

With only a couple of exceptions, there were no substantial changes between 2012 and 2018 in high school science teachers' ratings of preparedness (see Table 21). Among Earth/space teachers, the percentage of teachers who felt very well prepared to teach about Earth's features and physical processes decreased from 74 to 57 percent. Among chemistry teachers, the percentage that felt very well prepared to teach about atomic structure increased from 83 to 91 percent.

Table 21
High School Science Teachers Considering Themselves Very Well Prepared to Teach Each of a Number of Topics

	PERCENT OF TEACHERS[a]	
	2012	2018
Earth/Space Science		
Earth's features and physical processes*	74 (4.1)	57 (7.1)
The solar system and the universe	59 (4.9)	54 (6.9)
Climate and weather	60 (6.3)	54 (6.9)
Biology/Life Science		
Cell biology	75 (2.9)	75 (2.1)
Structures and functions of organisms	68 (3.1)	72 (2.9)
Genetics	69 (3.0)	71 (2.8)
Ecology/ecosystems	61 (2.7)	65 (2.8)
Evolution	56 (3.2)	63 (2.6)
Chemistry		
The periodic table	88 (3.2)	92 (1.9)
States, classes, and properties of matter	83 (3.2)	90 (1.9)
Elements, compounds, and mixtures	88 (3.2)	91 (1.9)
Atomic structure*	83 (3.2)	91 (1.7)
Chemical bonding, equations, nomenclature, and reactions	84 (3.4)	89 (1.8)
Properties of solutions	72 (3.4)	79 (2.4)
Physics		
Forces and motion	80 (3.7)	83 (3.8)
Energy transfers, transformations, and conservation	73 (4.5)	80 (3.7)
Properties and behaviors of waves	62 (4.3)	66 (3.8)
Electricity and magnetism	54 (4.0)	49 (4.7)
Modern physics	23 (2.7)	23 (2.8)
Environmental and Resource Issues (e.g., land and water use, energy resources and consumption, sources and impacts of pollution)	57 (6.7)	71 (5.8)

* There is a statistically significant difference between teachers in 2012 and teachers in 2018 (two-tailed independent samples t-test, $p < 0.05$).

[a] Each high school science teacher was asked about one set of science topics based on the discipline of their randomly selected class. High school multidisciplinary science teachers are not included in this table.

Table 22 displays mean scores for the composite variable Perceptions of Content Preparedness, which was defined based on the content of the randomly selected science class. The mean scores indicate that: (1) elementary teachers generally did not feel well prepared to teach science and (2) they felt less well prepared in 2018 than they did in 2012. Both findings suggest obstacles to implementing the NGSS in elementary grades. On a more positive note, high school teachers overall felt slightly better prepared in 2018 than they did in 2012.

Table 22
Mean Scores for Science Teachers' Perceptions of Content Preparedness Composite

	MEAN SCORE	
	2012	2018
Elementary		
Science (Grades K–5)*	55 (2.6)	50 (0.8)
Middle		
All Middle School Sciences	71 (1.2)	72 (0.8)
Life Science	76 (3.5)	82 (2.0)
Earth/Space Science	78 (2.8)	80 (2.3)
Physical Science	69 (3.5)	71 (2.2)
Integrated/General Science	66 (1.1)	66 (1.0)
High		
All High School Sciences*	85 (0.8)	88 (0.6)
Chemistry	93 (1.9)	96 (0.8)
Biology/Life Science	86 (1.5)	87 (0.8)
Earth/Space Science	84 (1.9)	82 (2.5)
Physics	80 (1.7)	81 (1.4)

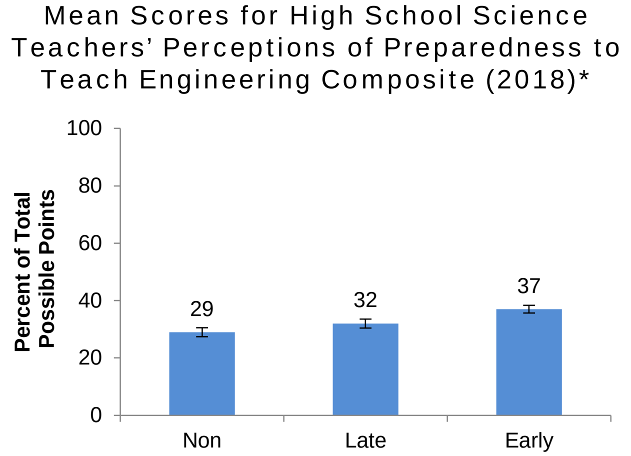
* There is a statistically significant difference between teachers in 2012 and teachers in 2018 (two-tailed independent samples t-test, $p < 0.05$).

Secondary science teachers were also asked about their preparedness to teach engineering, regardless of the discipline of their designated class. As can be seen in Table 23, very few middle and high school science teachers felt very well prepared to teach engineering concepts, and sizeable proportions indicated being not adequately prepared. This finding is not surprising given that few teachers have had college coursework in engineering and engineering has not historically been part of the school curriculum. K–12 teachers will likely need both high-quality curriculum and substantive professional development to be successful at integrating engineering into their science teaching, as recommended by the NGSS.

Table 23
Secondary Science Teachers' Perceptions of Their Preparedness to Teach Engineering

	PERCENT OF TEACHERS			
	NOT ADEQUATELY PREPARED	SOMEWHAT PREPARED	FAIRLY WELL PREPARED	VERY WELL PREPARED
Middle				
Developing possible solutions	28 (2.2)	32 (2.2)	26 (1.9)	14 (1.8)
Defining engineering problems	29 (2.1)	35 (2.3)	24 (2.0)	12 (1.6)
Optimizing a design solution	32 (2.2)	33 (2.2)	24 (1.9)	10 (1.6)
High				
Developing possible solutions	34 (1.9)	36 (1.9)	22 (1.4)	8 (0.8)
Defining engineering problems	38 (1.8)	38 (1.7)	18 (1.2)	7 (0.7)
Optimizing a design solution	42 (1.8)	36 (1.7)	16 (1.1)	6 (0.7)

High school teachers' preparedness to teach engineering varies based on NGSS-adoption status (see Figure 11), with teachers in early adopting states more likely than those in late-adopting or non-adopting states to feel prepared to teach engineering.



* There is a statistically significant difference between classes in early and late-adopting states and between classes in early and non-adopting states (two-tailed independent samples t-tests, $p < 0.05$).

Figure 11

Another series of items focused on teacher preparedness for a number of tasks associated with instruction. Specifically, teachers responded to several items about how well prepared they felt to monitor and address student understanding, focusing on a specific unit in the randomly selected class. As can be seen in Table 24, elementary teachers were less likely to feel very well prepared for each of these tasks than they did in 2012. For example, in 2012, 46 percent felt very well prepared to assess student understanding at the conclusion of the unit, compared to 32 percent in 2018. Among high school science teachers, there was a small decrease for the same item (from 64 to 59 percent), but otherwise there were no substantial changes among middle and high school teachers.

Table 24
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	
	2012	2018
Elementary		
Assess student understanding at the conclusion of this unit*	46 (2.2)	32 (1.8)
Monitor student understanding during this unit*	46 (2.2)	33 (1.9)
Implement the instructional materials to be used during this unit*,[a]	39 (2.7)	32 (2.0)
Anticipate difficulties that students may have with particular science ideas and procedures in this unit*	28 (1.8)	22 (1.9)
Find out what students thought or already knew about the key science ideas*	38 (1.8)	31 (2.2)
Middle		
Assess student understanding at the conclusion of this unit	59 (2.5)	58 (2.0)
Monitor student understanding during this unit	51 (2.2)	51 (2.1)
Implement the instructional materials to be used during this unit[a]	51 (2.9)	45 (2.4)
Anticipate difficulties that students may have with particular science ideas and procedures in this unit	39 (2.3)	37 (2.1)
Find out what students thought or already knew about the key science ideas	41 (2.4)	39 (2.1)
High		
Assess student understanding at the conclusion of this unit*	64 (1.6)	59 (1.8)
Monitor student understanding during this unit	57 (1.6)	53 (1.8)
Implement the instructional materials to be used during this unit[a]	52 (2.3)	53 (1.6)
Anticipate difficulties that students may have with particular science ideas and procedures in this unit	49 (1.5)	45 (1.6)
Find out what students thought or already knew about the key science ideas*	42 (1.4)	38 (1.6)

* There is a statistically significant difference between classes in 2012 and classes in 2018 (two-tailed independent samples t-test, $p < 0.05$).

[a] In 2012, this item was presented only to teachers who indicated using commercially published textbooks/modules in the most recent unit.

The items in Table 24 were combined to create a composite variable named Perceptions of Preparedness to Implement Instruction in Particular Unit. As can be seen in Table 25, feelings of preparedness increase with increasing grade range. What is also clear is that elementary teachers' feelings of preparedness decreased between 2012 and 2018.

Table 25
Mean Scores for Science Teachers' Perceptions of Preparedness to Implement Instruction in Particular Unit Composite

	MEAN SCORE	
	2012	2018
Elementary*	75 (0.8)	69 (0.9)
Middle	79 (0.8)	78 (0.9)
High	82 (0.6)	80 (0.5)

* There is a statistically significant difference between classes in 2012 and classes in 2018 (two-tailed independent samples t-test, $p < 0.05$).

Taken together, data on the science teaching force point to several challenges facing NGSS implementation. The majority of teachers hold many beliefs that align well with the NGSS, but these beliefs may not always translate into practice. Teachers' perceptions of preparedness tend to increase with increasing grade range. And while there is some evidence of movement in the right direction since the adoption of NGSS (particularly in the area of engineering), many obstacles remain. Many teachers have had limited coursework in the content they are expected to teach. For example, only one-third of elementary teachers and about half of middle school teachers meet NSTA's coursework recommendations. Trend data on secondary science teachers are more encouraging. Compared to 2012, these teachers were more likely in 2018 to have a degree in science, engineering, or science education. Trend data on elementary teachers suggest they felt less prepared to teach science in 2018 than they did in 2012, which, given the other challenges these teachers already face (e.g., lack of participation in science-focused professional development discussed below), point to a particular need for efforts that support NGSS implementation.

Professional Development

This section of the report discusses data in three areas:

- Participation in science professional development in the preceding three years;
- Characteristics of science professional development; and
- Emphasis of science 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 26, roughly 80 percent or more of secondary science teachers participated in discipline-focused professional development (i.e., focused on science content or the teaching of science) within the preceding three years. Elementary science teachers stand out for the relative lack of professional development in science or science teaching, with less than 60 percent having participated in the last three years. The data are largely unchanged since 2012, although there is a shift in the distribution among elementary teachers, which appears to be due to an increase in the percentage with no science professional development.

Table 26
Most Recent Participation in Science Professional Development

	PERCENT OF TEACHERS	
	2012	2018
Elementary*		
In the last 3 years	59 (2.0)	57 (2.2)
4–6 years ago	16 (1.4)	8 (1.2)
7–10 years ago	5 (0.8)	5 (0.7)
More than 10 years ago	5 (0.8)	6 (1.0)
Never	15 (1.4)	24 (1.5)
Middle		
In the last 3 years	82 (2.3)	78 (2.1)
4–6 years ago	6 (1.2)	6 (1.4)
7–10 years ago	3 (1.0)	2 (0.8)
More than 10 years ago	4 (1.3)	3 (0.8)
Never	6 (1.4)	11 (1.6)
High		
In the last 3 years	85 (1.3)	83 (1.3)
4–6 years ago	7 (0.7)	5 (0.8)
7–10 years ago	2 (0.3)	2 (0.4)
More than 10 years ago	1 (0.4)	2 (0.6)
Never	5 (1.0)	7 (0.9)

* There is a statistically significant difference in the distribution of the responses between teachers in 2012 and teachers in 2018 (Chi-square test of independence, $p < 0.05$).

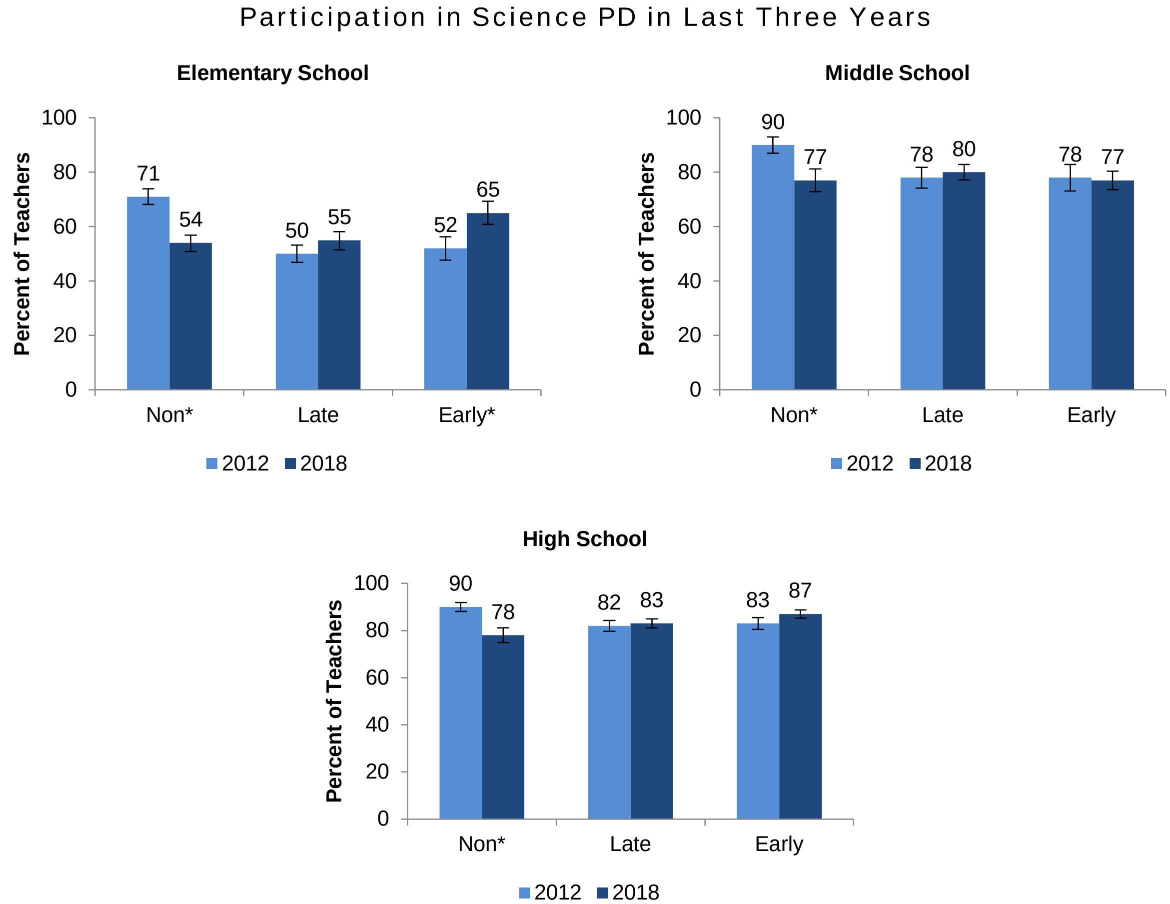
As can be seen in Table 27, about a quarter of middle school science teachers and about a third of high school science teachers participated in more than 35 hours of science professional development in the preceding three years. In contrast, 43 percent of elementary teachers had no science professional development in the last three years, which is particularly problematic for NGSS implementation. There were no changes in these data between 2012 and 2018.

Table 27
Time Spent on Science Professional Development in the Last Three Years†

	PERCENT OF TEACHERS	
	2012	2018
Elementary		
None	41 (2.0)	43 (2.2)
Less than 6 hours	24 (1.4)	20 (1.6)
6–15 hours	22 (1.7)	20 (1.5)
16–35 hours	8 (0.9)	12 (1.3)
More than 35 hours	4 (0.7)	5 (0.8)
Middle		
None	18 (2.3)	22 (2.2)
Less than 6 hours	12 (2.0)	8 (1.1)
6–15 hours	24 (1.8)	23 (2.4)
16–35 hours	20 (2.0)	21 (1.6)
More than 35 hours	27 (2.0)	26 (1.8)
High		
None	15 (1.4)	18 (1.3)
Less than 6 hours	8 (1.2)	8 (1.3)
6–15 hours	20 (1.1)	18 (1.6)
16–35 hours	21 (1.4)	22 (1.3)
More than 35 hours	36 (1.1)	34 (1.6)

† There are no significant differences between teachers in 2012 and teachers in 2018 (two-tailed independent samples t-tests, $p \geq 0.05$).

Some differences in professional development participation by NGSS-adoption status are evident in the data. Looking specifically at elementary grades, teachers in non-adopting states were less likely in 2018 than they were in 2012 to have had professional development in last three years (see Figure 12). This pattern holds among middle school and high school science teachers. Conversely, elementary teachers in early adopting states were more likely in 2018 to have had professional development in last three years.



* There is a statistically significant difference between teachers in 2012 and teachers in 2018 (two-tailed independent samples t-test, $p < 0.05$).

Figure 12

Teachers who had participated in professional development in the last three years were asked a series of questions about the nature of those experiences. The questions were designed to align with best practice in professional development[11]—for example, having opportunities to: (1) participate with other teachers from their school and those who have similar teaching assignments; (2) engage in investigations, both to learn disciplinary content and to experience inquiry-oriented learning; and (3) to apply what they have learned in their classrooms and subsequently discuss how it went.

As can be seen in Table 28, there were several changes between 2012 and 2018 in the professional development experiences of elementary science teachers. For example, these teachers were more likely in 2018 to have opportunities to work closely with other teachers from

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

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

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., 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.

their school (34 percent in 2012, 57 percent in 2018) and with other teachers who taught the same grade or subject, whether or not they were from their school (37 percent in 2012, 47 percent in 2018). The characteristics of professional development experiences for secondary teachers are largely unchanged.

Table 28
Science Teachers Whose Professional Development in the Last Three Years Had Each of a Number of Characteristics to a Substantial Extent[a]

	PERCENT OF TEACHERS	
	2012	2018
Elementary		
Worked closely with other teachers from their school*	34 (3.5)	57 (3.3)
Worked closely with other teachers who taught the same grade and/or subject whether or not they were from their school*	37 (3.4)	47 (3.2)
Had opportunities to engage in science investigations/engineering design challenges*,b	48 (3.5)	38 (3.0)
Had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction)	31 (3.5)	31 (2.9)
Had opportunities to apply what they learned to their classroom and then come back and talk about it as part of the professional development	34 (3.3)	30 (2.6)
Middle		
Worked closely with other teachers from their school	61 (3.5)	62 (3.5)
Worked closely with other teachers who taught the same grade and/or subject whether or not they were from their school	54 (4.0)	53 (3.0)
Had opportunities to engage in science investigations/engineering design challenges	52 (3.0)	46 (3.5)
Had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction)	40 (3.4)	38 (3.1)
Had opportunities to apply what they learned to their classroom and then come back and talk about it as part of the professional development	51 (4.5)	40 (3.1)
High		
Worked closely with other teachers from their school*	62 (2.6)	55 (2.3)
Worked closely with other teachers who taught the same grade and/or subject whether or not they were from their school	58 (2.6)	54 (2.1)
Had opportunities to engage in science investigations/engineering design challenges	45 (2.8)	45 (2.4)
Had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction)	33 (2.4)	39 (2.3)
Had opportunities to apply what they learned to their classroom and then come back and talk about it as part of the professional development	47 (2.4)	43 (2.4)

* There is a statistically significant difference between teachers in 2012 and teachers in 2018 (two-tailed independent samples t-test, $p < 0.05$).

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

b In 2012, this item read "Sponsors" instead of "Coordinates."

Responses to these five items describing the characteristics of professional development experiences were combined into a single composite variable called Extent Professional Development Aligns With Elements of Effective Professional Development. As can be seen in Table 29, the mean scores on this composite are all relatively low (on a 100-point scale), and there were no changes from 2012 to 2018. Similarly, there were no differences by NGSS-adoption status.

Table 29
Teacher Mean Scores for Extent Professional Development Aligns With Elements of Effective Professional Development Composite†

	PERCENT OF TEACHERS	
	2012	2018
Elementary	50 (1.9)	51 (1.5)
Middle	62 (1.8)	58 (1.3)
High	59 (1.3)	57 (1.0)

† There are no significant differences between teachers in 2012 and teachers in 2018 (two-tailed independent samples t-tests, $p \geq 0.05$).

Another series of items asked about the focus of professional development opportunities teachers had in the last three years. As can be seen in Table 30, little has changed since 2012. Roughly half of secondary science teachers' recent professional development heavily emphasized monitoring student understanding during science instruction and deepening their own science content knowledge. Among the few changes, professional development opportunities for elementary teachers were slightly less likely in 2018 to emphasize finding out what students think or already know prior to instruction on a topic (41 vs. 35 percent). Opportunities in this area for high school teachers decreased similarly (44 vs. 37 percent). Professional development opportunities for high school teachers also declined regarding monitoring student understanding during science instruction (55 vs. 47 percent) and learning about difficulties that students may have with particular science ideas (49 vs. 40 percent). Taken together, these data suggest less emphasis in 2018 on attention to student thinking in professional development opportunities.

Table 30
Science Teachers Reporting That Their Professional Development in the Last Three Years Gave Heavy Emphasis[a] to Various Areas

	PERCENT OF TEACHERS	
	2012	2018
Elementary		
Monitoring student understanding during science instruction	45 (3.0)	40 (3.3)
Deepening their own science content knowledge	37 (2.9)	39 (2.6)
Finding out what students think or already know prior to instruction on a topic	41 (2.8)	35 (3.0)
Implementing the science textbook/modules to be used in their classroom	39 (3.5)	34 (2.9)
Learning about difficulties that students may have with particular science ideas	30 (2.6)	26 (3.2)
Middle		
Monitoring student understanding during science instruction	54 (3.3)	47 (3.7)
Deepening their own science content knowledge	51 (4.0)	51 (3.3)
Finding out what students think or already know prior to instruction on a topic	46 (3.8)	42 (3.7)
Implementing the science textbook/modules to be used in their classroom	30 (2.9)	30 (3.1)
Learning about difficulties that students may have with particular science ideas	42 (3.1)	35 (3.0)
High		
Monitoring student understanding during science instruction*	55 (2.2)	47 (2.0)
Deepening their own science content knowledge	48 (2.1)	45 (1.9)
Finding out what students think or already know prior to instruction on a topic*	44 (2.3)	37 (2.0)
Implementing the science textbook/modules to be used in their classroom	29 (1.7)	29 (1.9)
Learning about difficulties that students may have with particular science ideas*	49 (2.5)	40 (2.0)

* There is a statistically significant difference between teachers in 2012 and teachers in 2018 (two-tailed independent samples t-test, $p < 0.05$).

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

Looking at these data by adoption status reveals only one difference in 2018 (see Figure 13). Encouragingly, professional development provided to teachers in early and late-adopting states was more likely than professional development provided to teachers in non-adopting states to heavily emphasize how science is done (e.g., developing scientific questions, developing and using models, engaging in argumentation).

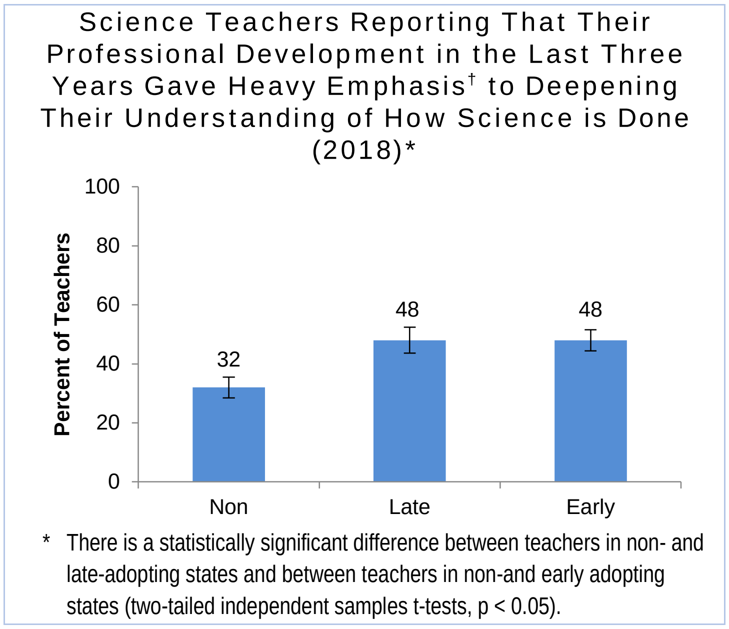


Figure 13

Unfortunately, some of these differences appear to have come at a cost. In early adopting states, the professional development that teachers participated in was considerably less likely to emphasize some aspects of science instruction in 2018 than in 2012, including difficulties students may have with science ideas and implementing science textbooks/modules (see Figure 14). Survey data discussed later in this report indicate that early adopters were likely to be using pre-NGSS textbooks, which may explain why professional development in 2018 was less likely to focus on these instructional materials. However, reasons for other decreases are unclear.

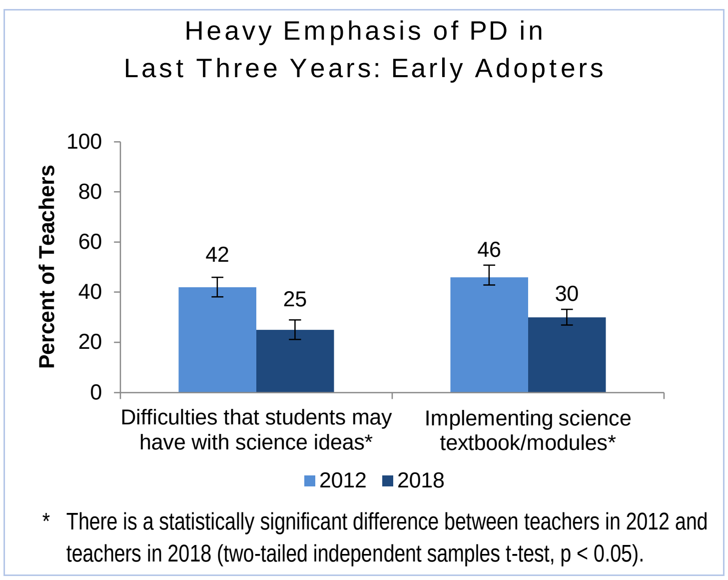


Figure 14

Teacher questionnaire data suggest teachers are not receiving the professional development they need in order to implement the NGSS. The 2018 NSSME+ also included a Science Program Questionnaire, which was completed by a person knowledgeable about school science programs, policies, and practices. School representatives were asked whether professional development workshops in science had been offered by their school and/or district, possibly in conjunction with other school districts, colleges/universities, museums, professional associations, or commercial vendors. As can be seen in Table 31, there was no change between 2012 and 2018, with about half or fewer schools, depending on grade range, having locally offered workshops on science.

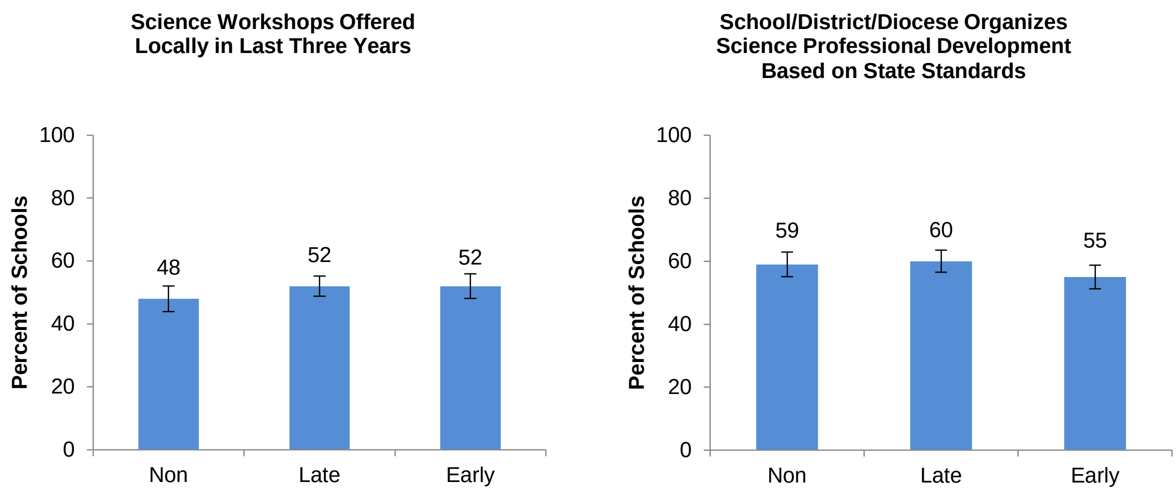
Table 31
Science Professional Development
Workshops Offered Locally in the Last Three Years†

	PERCENT OF SCHOOLS	
	2012	2018
Elementary	48 (2.9)	51 (2.8)
Middle	42 (3.6)	48 (2.6)
High	36 (4.0)	41 (2.9)

† There are no significant differences between schools in 2012 and schools in 2018 (two-tailed independent samples t-tests, $p \geq 0.05$).

Looking at 2018 data by NGSS-adoption status, there are no differences (see Figure 15). At best, only slightly more than half of schools in adopting states offered science workshops. Further, there were no differences in the likelihood of professional development being based on state standards. Both findings raise the question of where large proportions of teachers are finding opportunities for professional learning focused on the NGSS.

Professional Development Opportunities (2018)†



† There are no significant differences between schools in 2012 and schools in 2018 (two-tailed independent samples t-tests, $p \geq 0.05$).

Figure 15

The data on science professional development point to considerable obstacles to NGSS implementation. Elementary teachers in particular are unlikely to have participated in substantial amounts of professional development, and even among secondary science teachers, the proportion participating in more than 35 hours during the preceding three years is small. On a more positive note, there is some evidence that teachers in early adopting states were more likely to participate in professional development in 2018 than in 2012. Still, only about half of schools appear to be offering science-focused professional development, and the opportunities they do offer are frequently not focused on implementing state standards. All of these data raise the question: if the nation's 1.2 million teachers of science (approximately 80 percent of whom are elementary teachers) are not provided with professional learning opportunities that prepare them to implement the NGSS, how will they make the shift to NGSS-aligned instruction?

Instructional Materials

The quality and availability of instructional resources is a major factor in science teaching. The 2018 NSSME+ included a series of items on textbooks and instructional programs—which ones teachers use and how they use them. The following sections present these data, comparing them to 2012. It should be noted that at the time data were collected for this study (spring 2018) and at the writing of this report (fall 2019), very few NGSS-aligned instructional materials existed according to the two organizations that review materials for alignment (Achieve and EdReports). For example, of the 6 materials EdReports reviewed as of February 2020,[12] only 1 met expectations for NGSS alignment, and only 1 other partially met the expectations.

Use of Textbooks and Other Instructional Resources

When teachers responded that their randomly selected class had a designated instructional material (72 percent of elementary classes, 66 percent of middle grades classes, and 58 percent of high school classes), the survey presented them with a list of possible types of materials. Despite the increasing variety of instructional materials, it is clear that in 2018, the textbook still dominated, with the most commonly designated materials being commercially published textbooks and modules (see Table 32). The percentage of elementary and middle grades classes (39 percent each) that had fee-based websites as the designated material was considerably larger than in high school (16 percent). State- and district-developed resources were also relatively common in elementary grades. The data also indicate that for many classes, multiple types of materials were designated by the district.

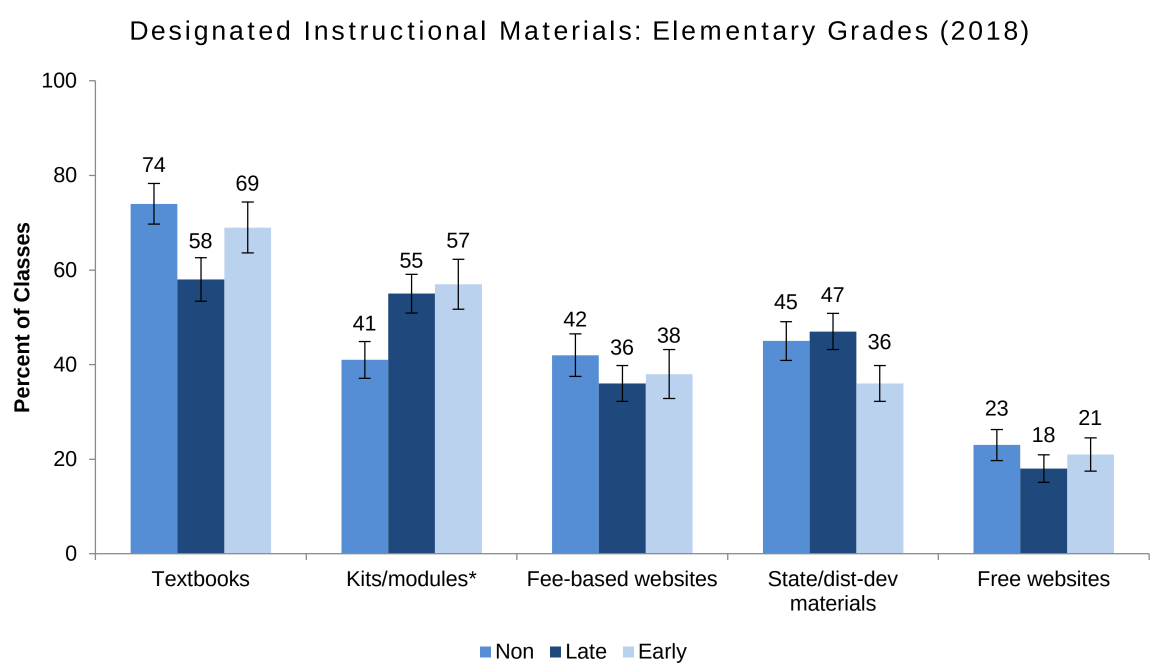
[12] *Free reviews of K-12 instructional materials*. (n.d.). EdReports. Retrieved February 14, 2020, from https://www.edreports.org/reports/

Table 32
Science Classes for Which Various Types of Instructional Resources Are Designated,† by Grade Range

	PERCENT OF CLASSES		
	ELEMENTARY	MIDDLE	HIGH
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	67 (2.9)	87 (1.8)	95 (0.9)
State, county, district, or diocese-developed units or lessons	43 (2.2)	32 (2.3)	27 (1.7)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	20 (1.9)	26 (2.2)	25 (2.0)
Commercially published kits/modules (printed or electronic)	51 (2.7)	36 (3.1)	22 (2.0)
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)	39 (2.7)	39 (2.8)	16 (1.5)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)	9 (1.2)	15 (2.0)	11 (1.8)

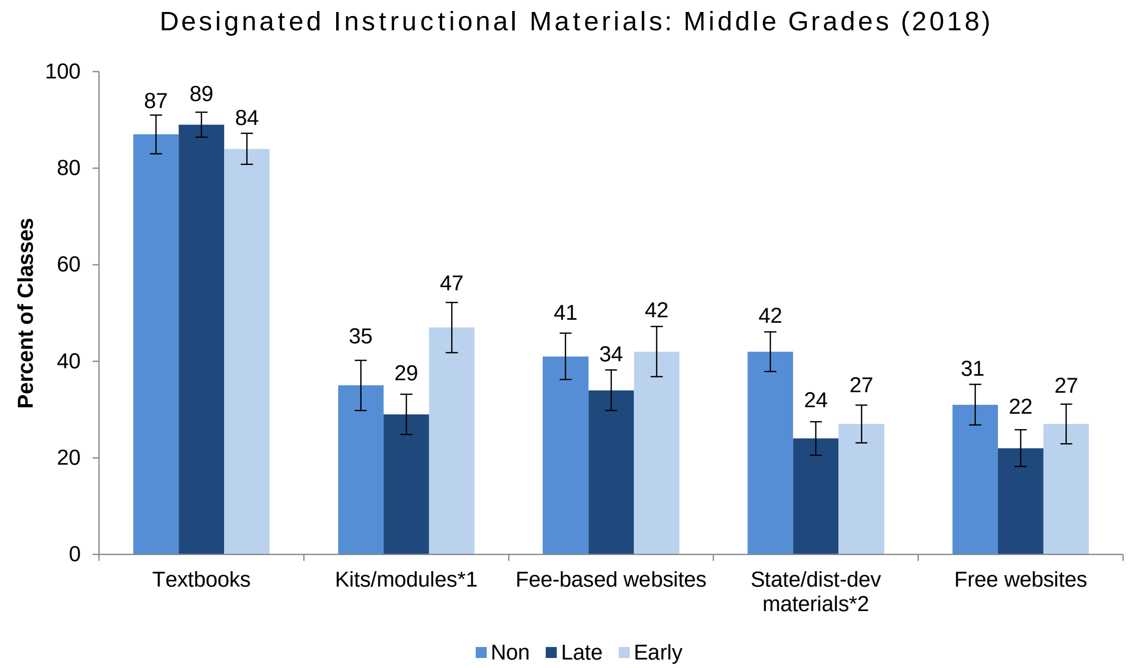
† Includes only those teachers who indicated that their randomly selected science class had an instructional material designated by the state, district, or diocese.

These data do vary somewhat by adoption status (see Figure 16). For example, at the elementary level, classes in early and late-adopting states were more likely than those in non-adopting states to have kits or modules designated for use. At the middle grades, classes in early and late-adopting states were much less likely than those in non-adopting states to have state/district-developed materials designated (see Figure 17). This latter finding is somewhat surprising, as one might expect states and districts would develop their own materials to fill the gap in NGSS-aligned materials. It also appears that classes in early adopting states were more likely than those in late- and non-adopting states to have kits or modules designated.



* There is a statistically significant difference between classes in non- and late-adopting states and between classes in non- and early adopting states (two-tailed independent samples t-tests, $p < 0.05$).

Figure 16



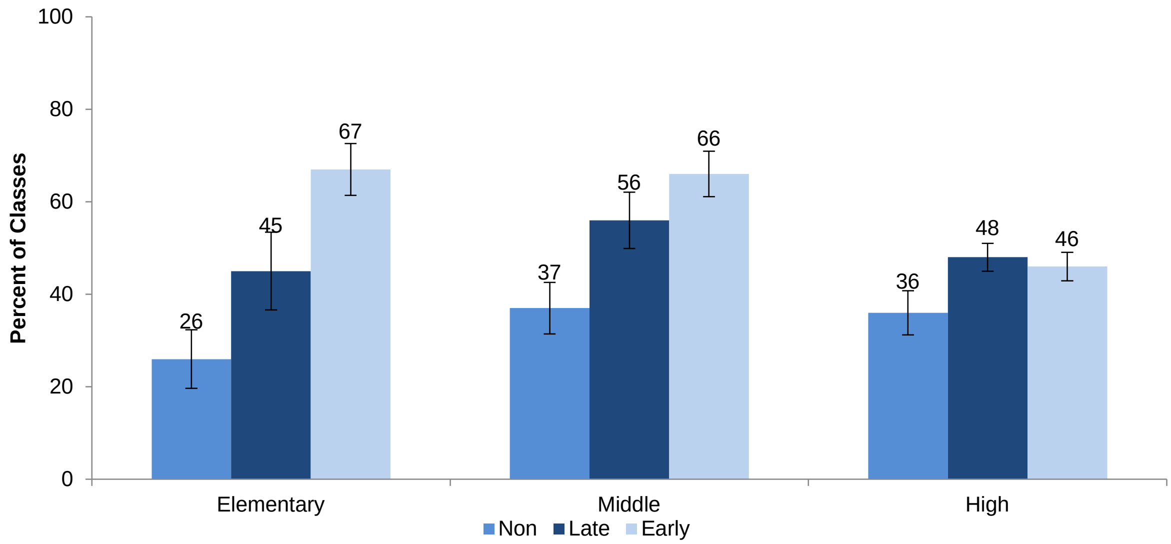
*1 There is a statistically significant difference between classes in early and late-adopting states (two-tailed independent samples t-test, $p < 0.05$).

*2 There is a statistically significant difference between classes in non- and late-adopting states and between classes in non-and early adopting states (two-tailed independent samples t-tests, $p < 0.05$).

Figure 17

If teachers said they based instruction in their randomly selected class on a commercially published material at least once a month (74 percent of elementary classes, 81 percent of middle grades classes, and 80 percent of high school classes), they answered several questions about the material, including the publication year. In elementary and middle grades, classes in early and late-adopting states were much more likely than those in non-adopting states to be using materials published prior to 2009, well before release of the NGSS (see Figure 18). This finding is counterintuitive as one would expect adopting states to be using post-NGSS materials to increase the likelihood of alignment. However, as mentioned previously, few aligned materials exist. Perhaps adopting states are waiting to select new materials until publishers catch up with the NGSS. What is clear is that about half or more of classes in NGSS states that are using commercially published textbooks, kits, or modules, are using materials published before 2009, including as many as two-thirds of elementary and middle grades classes in early adopting states.

Science Classes[a] Using
Textbooks/Kits/Modules Published in 2009 or Earlier (2018)



a Only classes using commercially published textbooks//kits/modules are included in these analyses.

Figure 18

When teachers responded that their most recent unit was based on a commercially published material or a material developed by the district or state (65 percent of elementary classes, 54 percent of middle grades classes, and 54 percent of high school classes), they were asked how they used the material (see Table 33). Two important findings emerge from these data. First, when classes use commercially published and state/district-developed materials, they heavily influence instruction at all grade ranges. Teachers in more than 70 percent of these classes across grade-level categories used the textbook substantially to guide the overall structure and content emphasis of their units. Second, it is clear that teachers modified their materials substantially when designing instruction. In roughly half or more of these classes, teachers incorporated activities from other sources substantially and picked some of the material while skipping other parts. At the elementary level, the pick-and-choose approach was more common in 2018 than in 2012 (51 and 42 percent of classes, respectively), perhaps reflecting teachers' attempts to align their materials with the NGSS. Looking at the data by adoption status lends support to this possibility (see Figure 19). In 2012, elementary classes in all states were equally likely to pick and choose from their materials. In 2018, teachers of classes in early and late-adopting states were considerably more likely than those in non-adopting states to pick some of the material and skip other parts.

Table 33
Ways Science Teachers Substantially[a] Used Their Textbook in Most Recent Unit[b]

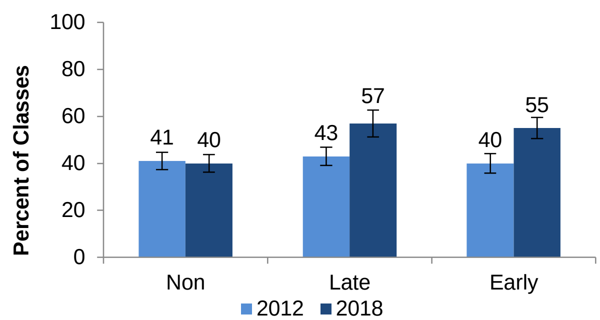
	PERCENT OF CLASSES	
	2012	2018
Elementary		
I used these materials to guide the structure and content emphasis of the unit.	77 (2.8)	77 (3.1)
I incorporated activities (e.g., problems, investigations, readings) from other sources to supplement what these materials were lacking.	64 (2.7)	65 (2.7)
I picked what is important from these materials and skipped the rest.*	42 (2.2)	51 (3.1)
Middle		
I used these materials to guide the structure and content emphasis of the unit.	66 (2.7)	72 (2.8)
I incorporated activities (e.g., problems, investigations, readings) from other sources to supplement what these materials were lacking.	75 (2.5)	78 (2.8)
I picked what is important from these materials and skipped the rest.	49 (3.2)	54 (3.4)
High		
I used these materials to guide the structure and content emphasis of the unit.*	64 (2.1)	76 (2.0)
I incorporated activities (e.g., problems, investigations, readings) from other sources to supplement what these materials were lacking.	79 (1.7)	78 (2.1)
I picked what is important from these materials and skipped the rest.	51 (2.0)	53 (2.6)

* There is a statistically significant difference between classes in 2012 and those in 2018 (two-tailed independent samples t-test, $p < 0.05$).

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

[b] Includes only those classes in which the most recent unit was based on a commercially published or state/district-developed material.

Classes in Which Elementary Teachers Picked What Was Important and Skipped the Rest*



* There is a statistically significant difference between classes in early and late-adopting states and between classes in early and non-adopting states (two-tailed independent samples t-tests, $p < 0.05$).

Figure 19

Summary

The data described in this report were collected in 2018, five years after release of the NGSS. The purpose of the analyses reported was to look for evidence of obstacles to and progress toward the NGSS vision, in part by comparing to similar data from 2012. Three themes emerged:

1. On many indicators of K–12 science instruction, little changed from 2012 to 2018.
2. Formidable obstacles to NGSS implementation remain, among them a lack of professional learning opportunities for teachers and a lack of NGSS-aligned instructional materials.
3. Comparing data from teachers and schools in early, late-, and non-adopting states reveals some differences, but for the most part, the results are similar regardless of NGSS-adoption status.

One area in which there was a difference by adoption status relates to instructional objectives. Classes in early and late-adopting states were less likely than those in non-adopting states to heavily emphasize learning science vocabulary and facts. They were also more likely to include at least some emphasis on engineering. However, there were no differences in emphasis on learning to do science, which is somewhat surprising given the NGSS's emphasis on science practices.

In the elementary grades, science instruction actually occurred less frequently in adopting states. In terms of instructional activities, lecture and discussion continued to be the predominant mode of instruction across grade ranges. Lecture was slightly less common in classes of early adopting states than in those of non-adopting states. Further, classes in early adopting states were somewhat more likely than those in non-adopting states to engage students in hands-on/ laboratory activities and to engage students in project-based learning activities. Classes in adopting states (both early and late) were more likely to give at least some attention to engineering in science instruction.

In terms of instruction related to science practices specifically, two patterns are apparent. First, regardless of grade range or adoption status, classes were more likely to emphasize practices related to conducting investigations and analyzing data than the aspects of science related to argumentation and evaluating the strengths and limitations of evidence. Second, classes in adopting states were no more or less likely than those in non-adopting states to emphasize the practices.

Overall, teachers' beliefs about science instruction align well with the NGSS. For example, at least 90 percent of teachers in each grade range agreed that teachers should ask students to support their conclusions about a science concept with evidence. Smaller, but still substantial, percentages held beliefs that run counter to the NGSS. Among them, over half of teachers agreed that hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned. Generally, teacher beliefs did not vary by adoption status. A notable exception is high school teachers' views on the importance of introducing vocabulary at the start of instruction, which teachers in adopting states were considerably less likely to agree with.

In terms of preparation to teach science, some findings are encouraging. Both middle and high school science teachers were more likely in 2018 than in 2012 to have a degree in science, science education, or engineering. The increase was particularly striking among middle and high school biology/life science teachers and among high school chemistry teachers. Among elementary teachers, the data are less positive. Only about a third met NSTA's recommendation of at least one course each in Earth, life, and physical science. Further, these data are unchanged since 2012. Perhaps more discouraging is evidence that elementary teachers felt less well prepared for science instruction than they did in 2012. Preparedness ratings of secondary science teachers were higher than those of elementary teachers, but there was little or no change compared to 2012. With regard to adoption status, only one difference stood out. High school science teachers in early adopting states considered themselves more prepared for engineering instruction than those in late- or non-adopting states.

Data on science-focused professional development generally suggest another obstacle to implementing the NGSS. Regardless of grade level or NGSS-adoption status, participation in professional development was low. A large majority of teachers had fewer than 35 hours of science-focused professional development in the preceding three years. Participation among elementary teachers was particularly low, although it does appear to have increased somewhat among teachers in early adopting states since 2012. Across grade ranges, only about half of schools reported offering science-focused professional development in the preceding three years. A more encouraging sign is that professional development in early and late-adopting states was more likely than that in non-adopting states to heavily emphasize deepening teachers' understanding of how science is done.

Finally, instructional materials continue to strongly influence science instruction. In 2018, more than two-thirds of science classes had a commercially published textbook as the designated instructional material, but there were some differences by adoption status. Elementary classes in early and late-adopting states were considerably more likely than those in non-adopting states to have commercially published kits or modules as their designated material. However, in adopting states, about half or more of classes using textbooks, kits, or modules were using ones published before well before the NGSS were released. In early adopting states, two-thirds of these elementary and middle grades classes were using pre-NGSS materials.

Taking these last two factors together—lack of professional development and lack of NGSS-aligned materials—perhaps it is not surprising that the 2018 NSSME+ found so few differences in science instruction or teacher characteristics between adopting and non-adopting states. These factors also highlight two areas that the field will need to address if the NGSS are to make inroads to the majority of the nation's classrooms.

APPENDIX

Recomputed Composite Definition

One composite was computed differently for this report than in an individual year's report to allow for comparisons between the two time points. Composite definitions for the 2012 and 2018 science teacher questionnaires (STQ) are presented below along with the item numbers from the respective questionnaires.

Table A-1
Extent Professional Development Aligns With Elements of Effective Professional Development†

	2012 STQ ITEM	2018 STQ ITEM
I had opportunities to engage in science investigations/engineering design challenges.	Q35a	Q33a
I had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction, e-portfolios).	Q35b	Q33c
I had opportunities to apply what I learned to my classroom and then come back and talk about it as part of the professional development.	Q35c	Q33e
I worked closely with other teachers from my school.	Q35d	Q33f
I worked closely with other teachers who taught the same grade and/or subject whether or not they were from my school.	Q35e	Q33g
Number of Items in Composite	5	5
Reliability – Cronbach's Coefficient Alpha	0.72	0.68
Confirmatory Factor Analysis Fit Index – SRMR	0.05	0.05

† These items were presented only to teachers who participated in science-related professional development in the last three years.