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A Comparison of Novice and Veteran Science Teachers: Data From the 2018 NSSME+

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Peggy J. Trygstad

Disclaimer

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Additional Information

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

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Introduction

In 2018, the National Science Foundation supported the sixth in a series of surveys through a grant to Horizon Research, Inc. The first survey was conducted in 1977 as part of a major assessment of science and mathematics education and consisted of a comprehensive review of the literature; case studies of 11 districts throughout the United States; and a national survey of teachers, principals, and district and state personnel. A second survey of teachers and principals was conducted in 1985–86 to identify trends since 1977. A third survey was conducted in 1993, a fourth in 2000, and a fifth in 2012. This series of studies has been known as the National Survey of Science and Mathematics Education (NSSME).

The 2018 iteration of the study included an emphasis on computer science, particularly at the high school level, which is increasingly prominent in discussions about K–12 STEM education and college and career readiness. The 2018 NSSME+ (the plus symbol reflecting the additional focus) was designed to provide up-to-date information and to identify trends in the areas of teacher background and experience, curriculum and instruction, and the availability and use of instructional resources. The research questions addressed by the study were:

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+ was 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.

This report describes novice[1] and veteran science teachers in the United States, with particular emphasis on the similarities and differences between these two groups. Although the focus of the 2018 NSSME+ was not on novices, the dataset includes 889 teachers who reported being in their first five years of teaching science, including 262 elementary grades teachers (defined as teaching any grade K–5 or teaching a self-contained 6th grade class), 238 middle grades teachers (teaching any grade 6–8), and 389 high school teachers (grades 9–12). Because of the sample design and the use of design weights in analysis, results of the 2018 NSSME+ are nationally representative. Consequently, the results presented in this report should be interpreted as indicative of all novice and veteran science teachers, not just those who participated in the study. The standard errors for the estimates presented in this report are included in parentheses in the tables. Details on the survey sample design, data collection and analysis procedures, and creation of composite variables[2] are included in the *Report of the 2018 NSSME+*.[3]

This report is divided into five main sections. The first section provides data about the school contexts in which teachers worked. The second highlights characteristics of teachers themselves, including sex, race/ethnicity, age, and experience. The third section describes preparation for teaching science, including college degrees, science coursework, and professional development experiences. Section four provides data about teachers' beliefs about teaching and learning and perceptions of preparedness to teach science. The fifth section describes the nature of instruction in teachers' classrooms, including objectives for instruction, instructional strategies used, and availability of resources. The report concludes with a summary.

School Contexts

Although the focus of this report is on teachers and their science instruction, the 2018 NSSME+ provided some information about the school contexts in which teachers worked. Most tables in this section show the percentages of novices and veterans who worked in schools with various characteristics, including factors that support effective instruction and those that may get in the way.

Table 1 shows the percentages of novice and veteran science teachers who worked in schools with various characteristics. The distribution of school type (Catholic schools, Non-Catholic private schools, and public schools) was roughly the same for novices as it was for veterans, with the vast majority of teachers working in public schools. Further, there was no difference in the distribution of novices and veterans among urban, suburban, and rural school settings. However, looking at the distribution of teachers based on the percent of students in school eligible for free or reduced-price lunch, novice science teachers appear to be more likely than veteran science teachers to teach in higher-poverty schools (i.e., those with higher proportions of students who qualify for free or reduced-price lunch).

1 For this report, novices are defined as teachers in their first five years of teaching science.

2 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.

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

Table 1
School Characteristics

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
School Type		
Catholic	5 (1.1)	4 (0.6)
Non-Catholic Private	4 (1.2)	4 (0.8)
Public	91 (1.6)	92 (1.1)
Community Type		
Rural	22 (2.5)	20 (1.4)
Suburban	48 (3.1)	54 (1.7)
Urban	30 (3.0)	25 (1.3)
Percent of Students in School Eligible for FRL*		
Lowest Quartile	21 (3.0)	27 (2.3)
Second Quartile	18 (2.7)	25 (3.0)
Third Quartile	30 (3.8)	24 (2.5)
Highest Quartile	30 (3.9)	24 (2.7)

* There is a statistically significant difference in the distribution of responses between schools in which novice and veteran teachers tended to work (Chi-square test of independence, $p < 0.05$).

Another characteristic of schools is the amount of money spent per pupil on science resources (including equipment, consumable supplies, and software) in a given year. As can be seen in Table 2, novice science teachers at the elementary level tended to work in schools where the median per-pupil spending was almost half that of schools where veterans tended to work ($1.09 vs. $2.07 per pupil).

Table 2
School Spending Per Pupil

	MEDIAN AMOUNT	
	NOVICE	VETERAN
Elementary*	$1.09 (0.4)	$2.07 (0.5)
Middle	$1.98 (0.3)	$2.73 (0.5)
High	$6.36 (0.9)	$7.96 (0.7)

* There is a statistically significant difference between schools in which novice and veteran teachers tended to work (two-tailed independent samples t-test, $p < 0.05$).

The extent to which state standards influence school practices can also have an effect on science instruction. As can be seen in Table 3, large percentages of novices and veterans across grade bands worked in schools reporting that most teachers teach to their state science standards, participate in school-wide efforts to align science instruction with state science standards, and thoroughly discuss state science standards with other science teachers in their schools. There are no significant differences between schools where novices and veterans tended to work.

Table 3
Influence[a] of State Science Standards in Schools[†]

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Elementary		
Most science teachers in this school teach to the state standards.	79 (3.2)	78 (3.0)
There is a school-wide effort to align science instruction with the state science standards.	68 (4.1)	71 (3.2)
State science standards have been thoroughly discussed by science teachers in this school.	63 (4.7)	66 (3.3)
This school/district/diocese organizes science professional development based on state standards.	52 (5.1)	57 (3.5)
Middle		
Most science teachers in this school teach to the state standards.	91 (3.2)	92 (2.1)
There is a school-wide effort to align science instruction with the state science standards.	90 (2.8)	88 (3.2)
State science standards have been thoroughly discussed by science teachers in this school.	87 (3.3)	87 (3.3)
This school/district/diocese organizes science professional development based on state standards.	63 (5.5)	68 (3.8)
High		
Most science teachers in this school teach to the state standards.	87 (3.2)	89 (1.8)
There is a school-wide effort to align science instruction with the state science standards.	87 (3.3)	87 (2.0)
State science standards have been thoroughly discussed by science teachers in this school.	80 (3.8)	87 (1.9)
This school/district/diocese organizes science professional development based on state standards.	64 (4.1)	66 (2.7)

† There are no significant differences between schools in which novice and veteran teachers tended to work (two-tailed independent samples t-test, $p \geq 0.05$).

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

By combining these items into a composite variable, an overview of the influence of standards in schools can be seen. At the elementary level, the mean scores suggest that state standards moderately influenced science instruction (see Table 4). However, the mean scores for the middle and high school grade bands indicate that teachers generally worked in schools where state science standards wielded a great deal of influence. There are no significant differences in the focus on state standards between schools where novices and veterans tended to work at any of the grade bands.

Table 4
Mean Scores for School Focus on State Science Standards Composite[†]

	MEAN SCORE	
	NOVICE	VETERAN
Elementary	66 (2.1)	66 (1.9)
Middle	80 (1.9)	80 (2.0)
High	76 (1.7)	78 (1.1)

† There are no significant differences between schools in which novice and veteran teachers tended to work (two-tailed independent samples t-test, $p \geq 0.05$).

A number of other school-level factors can also impact science instruction. As can be seen in Table 5, novices and veterans at all three grade bands tended to work in schools reporting that science professional development policies and practices, the importance that the school places on science, and how science instructional resources are managed tended to promote effective science instruction. However, at the elementary level, novices were less likely than veterans to work in schools where other initiatives (28 vs. 39 percent) or the amount of time provided for teacher professional development in science (23 vs. 33 percent) promoted effective science instruction. There are no differences between schools in which novices and veterans at the middle or high school grade bands tended to work in the extent to which these school factors supported science instruction.

Table 5
Factors Promoting[a] Effective Science Instruction

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Elementary		
The school/district/diocese science professional development policies and practices	51 (4.5)	51 (3.3)
The importance that the school places on science	43 (5.1)	47 (3.8)
How science instructional resources are managed (e.g., distributing and refurbishing materials)	39 (5.7)	50 (4.0)
The amount of time provided by the school/district/diocese for teachers to share ideas about science instruction	30 (4.4)	32 (3.0)
Other school and/or district/diocese initiatives*	28 (4.1)	39 (3.5)
The amount of time provided by the school/district/diocese for teacher professional development in science*	23 (3.9)	33 (3.2)
Middle		
The school/district/diocese science professional development policies and practices	55 (4.9)	62 (3.4)
The importance that the school places on science	51 (4.0)	50 (3.4)
How science instructional resources are managed (e.g., distributing and refurbishing materials)	48 (4.1)	50 (4.4)
The amount of time provided by the school/district/diocese for teacher professional development in science	47 (4.8)	47 (3.6)
Other school and/or district/diocese initiatives	40 (4.8)	39 (3.5)
The amount of time provided by the school/district/diocese for teachers to share ideas about science instruction	53 (5.1)	49 (3.6)
High		
The school/district/diocese science professional development policies and practices	61 (4.2)	54 (3.0)
The importance that the school places on science	64 (4.2)	70 (3.0)
How science instructional resources are managed (e.g., distributing and refurbishing materials)	57 (4.0)	61 (3.0)
The amount of time provided by the school/district/diocese for teacher professional development in science	44 (3.6)	46 (3.1)
Other school and/or district/diocese initiatives	39 (3.6)	36 (2.9)
The amount of time provided by the school/district/diocese for teachers to share ideas about science instruction	47 (4.0)	51 (3.1)

* There is a statistically significant difference between schools in which novice and veteran teachers tended to work (two-tailed independent samples t-test, $p < 0.05$).

a Includes schools that indicated 4 or 5 on a five-point scale ranging from 1 “inhibits effective instruction” to 5 “promotes effective instruction.”

These items were combined into a composite variable to look at the effects of these factors on science instruction more holistically. The modest mean scores (ranging from 51 to 64) suggest that school contexts were only moderately supportive of science instruction. There are no significant differences in the supportiveness of context in the schools where novices and veterans tended to work.

Table 6
Mean Scores for School
Supportive Context for Science Instruction Composite†

	MEAN SCORE	
	NOVICE	VETERAN
Elementary	51 (2.7)	55 (1.7)
Middle	62 (1.6)	60 (2.3)
High	64 (1.8)	63 (1.5)

† There are no significant differences between schools in which novice and veteran teachers tended to work (two-tailed independent samples t-test, $p \geq 0.05$).

Teacher issues (e.g., lack of interest, high turnover), student issues (e.g., low prior knowledge and skills, high absenteeism), and lack of resources (e.g., science facilities, textbooks/modules) are also school-level factors that can impact science instruction. At the elementary level, some of these factors were problematic in schools where novices and veterans tended to work. As can be seen in Table 7, over three-quarters of novice and veteran science teachers worked in schools where inadequate science-related professional development opportunities and insufficient instructional time to teach science were reported to be problematic. However, novice elementary teachers faced additional challenges. Perhaps not surprisingly, novices were more likely than veterans to work in schools where high teacher turnover was problematic (47 vs. 29 percent). Novices were also more likely than veterans to work in schools where low student prior knowledge and skills (75 vs. 65 percent), inappropriate student behavior (53 vs. 43 percent), and high student absenteeism (42 vs. 31 percent) were seen as problematic. In terms of resources, 65 percent of novices worked in schools where inadequate funds for purchasing science equipment and supplies was deemed problematic, compared to 56 percent of veterans.

Table 7
Factors Reported by Schools as Problematic for Elementary Science Instruction

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Inadequate science-related professional development opportunities	78 (4.3)	76 (2.7)
Insufficient instructional time to teach science	77 (4.6)	80 (3.0)
Low student prior knowledge and skills*	74 (3.3)	65 (3.2)
Inadequate materials for differentiating science instruction	72 (4.1)	66 (3.3)
Lack of science facilities (e.g., lab tables, electric outlets, faucets and sinks in classrooms)	67 (4.0)	59 (4.1)
Inadequate teacher preparation to teach science	66 (4.3)	65 (3.2)
Inadequate funds for purchasing science equipment and supplies*	65 (4.8)	56 (3.9)
Lack of parent/guardian support and involvement	55 (4.9)	48 (3.3)
Lack of teacher interest in science	53 (5.6)	52 (3.4)
Lack of science textbooks/modules	53 (5.2)	48 (3.6)
Inappropriate student behavior*	53 (4.7)	43 (3.3)
Poor quality science textbooks/modules	51 (5.7)	52 (3.4)
Large class sizes	49 (4.8)	47 (4.0)
High teacher turnover*	47 (4.8)	29 (3.3)
High student absenteeism*	42 (4.6)	31 (3.0)
Low student interest in science	25 (4.1)	25 (2.9)
Community resistance to the teaching of "controversial" issues in science (e.g., evolution, climate change)	12 (3.0)	13 (2.4)

* There is a statistically significant difference between schools in which novice and veteran teachers tended to work (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes schools that indicated 2 or 3 on a three-point scale ranging from 1 "not a significant problem" to 3 "serious problem."

Three composite variables created from these items: Extent to Which Teacher Issues are Problematic, Extent to Which a Lack of Resources is Problematic, and Extent to Which Student Issues are Problematic (see Table 8). The mean scores indicate that teacher issues and lack of resources were equally problematic at the elementary level in schools where novices and veterans tended to work. Student issues, although perhaps less problematic overall, were slightly more pronounced in schools where novice science teachers tended to work than in those where veterans tended to work (mean scores of 28 vs. 24).

Table 8
Mean Scores for School Factors Affecting Elementary Science Instruction Composites

	MEAN SCORE	
	NOVICE	VETERAN
Extent to Which Teacher Issues are Problematic	47 (2.6)	45 (1.8)
Extent to Which a Lack of Resources is Problematic	41 (2.8)	38 (2.2)
Extent to Which Student Issues are Problematic*	28 (1.9)	24 (1.4)

* There is a statistically significant difference between schools in which novice and veteran teachers tended to work (two-tailed independent samples t-test, $p < 0.05$).

At the middle and high school grade bands, a number of factors stand out as problematic in schools where novices and veterans worked. For example, roughly 60–70 percent of teachers indicated that low student prior knowledge and skills, lack of parent/guardian support and involvement, inadequate funds for purchasing science equipment and supplies, inadequate materials for differentiating science instruction, and large class sizes were problematic (see Tables 9 and 10). In addition, low student interest in science and inadequate science-related professional development opportunities were reported to be problematic by over half of teachers at the high school level.

A few factors were more likely to be perceived as problematic in schools where novice secondary teachers tended to work compared to schools where their veteran counterparts tended to work. At the middle school level, novices were more likely than veterans to work in schools where inadequate funds for purchasing science equipment and supplies were considered to be problematic (67 vs. 58 percent). And at both the middle school and high school grade bands, novices were more likely than veterans to be in schools where high teacher turnover was viewed as problematic (53 vs. 32 percent and 45 vs. 34 percent, respectively).

Table 9

Factors Reported by Schools as Problematic[a] for Middle School Science Instruction

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Low student prior knowledge and skills	73 (4.4)	68 (3.1)
Lack of parent/guardian support and involvement	67 (4.8)	60 (3.2)
Inadequate funds for purchasing science equipment and supplies*	67 (4.2)	58 (3.4)
Inadequate materials for differentiating science instruction	66 (4.4)	64 (2.9)
Large class sizes	65 (4.7)	68 (3.2)
Inadequate science-related professional development opportunities	60 (3.9)	58 (3.2)
High student absenteeism	60 (5.1)	53 (3.3)
Inappropriate student behavior	57 (4.6)	56 (3.3)
Lack of science facilities (e.g., lab tables, electric outlets, faucets and sinks in classrooms)	54 (4.9)	51 (3.4)
High teacher turnover*	53 (4.2)	32 (3.3)
Low student interest in science	52 (5.0)	52 (3.6)
Poor quality science textbooks/modules	47 (4.1)	50 (3.6)
Lack of science textbooks/modules	44 (4.8)	43 (3.2)
Insufficient instructional time to teach science	40 (4.5)	43 (3.6)
Inadequate teacher preparation to teach science	28 (4.1)	33 (3.5)
Community resistance to the teaching of "controversial" issues in science (e.g., evolution, climate change)	18 (3.9)	21 (3.6)
Lack of teacher interest in science	15 (3.9)	13 (3.3)

* There is a statistically significant difference between schools in which novice and veteran teachers tended to work (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes schools that indicated 2 or 3 on a three-point scale ranging from 1 "not a significant problem" to 3 "serious problem."

Table 10
Factors Reported by Schools as Problematic[a] for High School Science Instruction

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Low student prior knowledge and skills	75 (3.4)	69 (2.7)
Low student interest in science	59 (3.8)	53 (3.2)
Inadequate science-related professional development opportunities	58 (4.0)	61 (3.0)
Large class sizes	58 (4.5)	60 (2.8)
Lack of parent/guardian support and involvement	58 (4.5)	58 (2.9)
High student absenteeism	57 (4.3)	55 (3.2)
Inadequate materials for differentiating science instruction	53 (3.5)	50 (2.6)
Inadequate funds for purchasing science equipment and supplies	48 (3.6)	45 (2.6)
Inappropriate student behavior	46 (4.2)	43 (3.5)
High teacher turnover*	45 (4.2)	34 (3.0)
Insufficient instructional time to teach science	44 (4.0)	47 (3.1)
Lack of science facilities (e.g., lab tables, electric outlets, faucets and sinks in classrooms)	39 (3.3)	39 (2.5)
Poor quality science textbooks/modules	38 (3.6)	38 (2.8)
Lack of science textbooks/modules	35 (4.3)	32 (2.9)
Inadequate teacher preparation to teach science	25 (3.6)	25 (2.9)
Community resistance to the teaching of "controversial" issues in science (e.g., evolution, climate change)	14 (2.6)	17 (1.9)
Lack of teacher interest in science	13 (3.4)	9 (1.8)

* There is a statistically significant difference between schools in which novice and veteran teachers tended to work (two-tailed independent samples t-test, $p < 0.05$).

[a] Includes schools that indicated 2 or 3 on a three-point scale ranging from 1 "not a significant problem" to 3 "serious problem."

These items were combined into three composite variables. The modest mean scores suggest that teacher issues, student issues, and lack of resources did not affect instruction to a great extent at the middle or high school levels (see Table 11). Further, there are no significant differences in perceptions of factors affecting science instruction, suggesting that novices and veterans tended to work in schools where these factors were similarly problematic for science instruction.

Table 11
Mean Scores for School Factors Affecting
Secondary School Science Instruction Composites[†]

	MEAN SCORE	
	NOVICE	VETERAN
Middle		
Extent to Which a Lack of Resources is Problematic	37 (2.6)	35 (1.9)
Extent to Which Student Issues are Problematic	35 (2.4)	34 (1.8)
Extent to Which Teacher Issues are Problematic	23 (2.1)	23 (1.9)
High		
Extent to Which a Lack of Resources is Problematic	26 (1.7)	25 (1.3)
Extent to Which Student Issues are Problematic	34 (2.0)	31 (1.5)
Extent to Which Teacher Issues are Problematic	21 (1.4)	21 (1.1)

† There are no significant differences between schools in which novice and veteran teachers tended to work (two-tailed independent samples t-test, $p \geq 0.05$).

Another characteristic of schools that is particularly important for novices is the availability of induction programs. As can be seen in Table 12, three-quarters or more of novice teachers at each grade band worked in schools with induction programs, ranging in duration from less than one year to more than three years.

Table 12
Duration of School Induction Program

	PERCENT OF NOVICE TEACHERS		
	ELEMENTARY	MIDDLE	HIGH
School offers no formal induction program	19 (3.8)	25 (4.9)	21 (3.6)
School offers an induction program of one year or less	37 (4.2)	32 (5.0)	34 (3.5)
School offers an induction program of two years	22 (4.0)	27 (4.8)	31 (3.7)
School offers an induction program of three or more years	22 (3.6)	16 (3.3)	14 (2.5)

Within these induction programs, a number of supports were very common across grade bands. These supports included meetings to orient teachers to school/district/diocese policies and practices, formally assigned school-based mentors, professional development opportunities on teaching in their subject, release time to observe other teachers in their grade/subject area, and common planning time with experience teachers who teach the same subject or grade level (see Table 13).

Table 13
Supports Provided by Schools as Part of Formal Induction Programs, by Grade Range

	PERCENT OF NOVICE TEACHERS[a]		
	ELEMENTARY	MIDDLE	HIGH
A meeting to orient them to school/district/diocese policies and practices	92 (3.0)	97 (1.8)	92 (2.0)
Formally assigned school-based mentor teachers	85 (3.1)	86 (3.6)	84 (2.9)
Professional development opportunities on teaching their subject	84 (3.6)	85 (3.7)	72 (3.7)
Release time to observe other teachers in their grade/subject area	81 (4.6)	69 (5.8)	64 (4.0)
Common planning time with experienced teachers who teach the same subject or grade level	82 (4.1)	75 (5.0)	62 (3.4)
Professional development opportunities on providing instruction that meets the needs of students from the cultural backgrounds represented in your school	46 (3.9)	56 (4.9)	60 (3.7)
Release time to attend national, state, or local teacher conferences	37 (5.1)	39 (5.0)	43 (3.8)
Financial support to attend national, state, or local teacher conferences	19 (4.0)	24 (4.4)	34 (3.5)
Supplemental funding for classroom supplies	37 (5.6)	32 (4.1)	29 (3.2)
District/diocese-based or university-based mentors	29 (5.1)	35 (4.8)	27 (3.8)
Classroom aides/teaching assistants	19 (4.4)	11 (2.6)	19 (3.7)
Reduced number of teaching preps	1 (0.8)	14 (3.0)	17 (3.0)
Reduced course load	3 (1.8)	3 (1.5)	4 (1.7)
Reduced class size	0 ---[b]	1 (1.0)	2 (0.9)

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

[b] No elementary schools in the sample at which novice science teachers worked selected this response option. Thus, it is not possible to calculate the standard error of this estimate.

Teacher Characteristics

The 2018 NSSME+ provided information about the demographic characteristics of science teachers. As can be seen in Table 14, large percentages of novices and veterans, across all three grade bands, were female. This pattern is particularly striking in the elementary level where over 90 percent of novices and veterans were female.

Table 14
Teacher Sex†

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Elementary		
Female	96 (1.3)	93 (1.0)
Male	4 (1.3)	7 (1.0)
Other	0 ---[a]	0 (0.2)
Middle		
Female	68 (3.9)	73 (2.2)
Male	32 (3.9)	27 (2.3)
Other	0 ---[a]	1 (0.3)
High		
Female	58 (3.4)	56 (2.0)
Male	42 (3.4)	44 (2.0)
Other	0 (0.1)	0 ---[a]

† There are no significant differences in the distribution of responses between novice and veteran teachers (Chi-square test of independence, $p \geq 0.05$).

[a] No science teachers in the sample selected this response option. Thus, it is not possible to calculate the standard error of this estimate.

Not surprisingly, novice science teachers tend to be younger than veterans. As can be seen in Table 15, the modal age of novice teachers at each grade range was less than or equal to 30 years of age.

Table 15
Teacher Age

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Elementary*		
≤ 30	56 (3.4)	5 (1.0)
31–40	25 (2.8)	29 (1.8)
41–50	15 (2.8)	34 (2.0)
51–60	3 (1.3)	26 (1.9)
61+	1 (0.7)	6 (1.1)
Middle*		
≤ 30	44 (4.9)	4 (1.5)
31–40	33 (4.1)	28 (2.8)
41–50	12 (2.4)	32 (2.4)
51–60	8 (2.8)	25 (2.4)
61+	3 (1.8)	11 (2.0)
High*		
≤ 30	50 (3.1)	3 (0.5)
31–40	32 (3.3)	31 (1.9)
41–50	11 (1.9)	33 (1.6)
51–60	5 (2.1)	25 (1.5)
61+	2 (0.8)	9 (1.0)

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

In 2018, individuals from race/ethnicity groups historically underrepresented in the teaching profession continued to be underrepresented in science classrooms. As can be seen in Table 16, approximately 90 percent of novice and veteran science teachers at each grade band characterized themselves as White.

Table 16
Teacher Race/Ethnicity

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Elementary		
White	88 (2.2)	88 (1.8)
Black or African American	10 (1.9)	8 (1.4)
Hispanic/Latino	10 (2.8)	8 (1.6)
Asian*	5 (1.7)	1 (0.5)
American Indian or Alaskan Native	1 (0.6)	2 (0.7)
Native Hawaiian or Other Pacific Islander	0 ---[a]	1 (0.5)
Middle		
White	89 (2.7)	92 (1.5)
Black or African American	11 (2.8)	7 (1.5)
Hispanic/Latino	8 (2.4)	6 (1.3)
Asian	2 (1.0)	1 (0.5)
American Indian or Alaskan Native	2 (0.8)	2 (0.8)
Native Hawaiian or Other Pacific Islander	1 (0.7)	0 ---[a]
High		
White	87 (2.7)	93 (1.2)
Black or African American	6 (1.5)	4 (1.0)
Hispanic/Latino*	11 (2.4)	5 (0.7)
Asian	7 (2.4)	4 (0.9)
American Indian or Alaskan Native	2 (0.6)	2 (0.6)
Native Hawaiian or Other Pacific Islander	0 (0.3)	0 (0.2)

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

[a] No science teachers in the sample selected this response option. Thus, it is not possible to calculate the standard error of this estimate.

Survey data indicate that many novice science teachers were new to the teaching profession in general, not just science. As can be seen in Table 17, the large majority of novices at each grade range had five or fewer years' experience teaching any subject at the K–12 level. This finding, and the fact that about half of novice science teachers were over the age of 30, suggests that teaching was a second career for many of them.

Table 17
Experience Teaching Any Subject at the K–12 Level

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Elementary*		
0–2 years	43 (3.6)	0 ---[a]
3–5 years	44 (3.8)	5 (1.0)
6–10 years	8 (2.0)	22 (2.0)
11–20 years	4 (1.5)	46 (2.5)
≥ 21 years	1 (0.6)	27 (1.9)
Middle*		
0–2 years	47 (5.1)	0 ---[a]
3–5 years	31 (5.3)	5 (1.1)
6–10 years	11 (2.1)	21 (2.3)
11–20 years	8 (2.2)	48 (3.1)
≥ 21 years	3 (1.7)	26 (3.3)
High*		
0–2 years	52 (4.0)	0 ---[a]
3–5 years	39 (3.6)	6 (0.9)
6–10 years	4 (1.5)	21 (1.9)
11–20 years	5 (2.1)	47 (2.2)
≥ 21 years	1 (0.3)	26 (1.7)

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

[a] No science teachers in the sample selected this response option. Thus, it is not possible to calculate the standard error of this estimate.

Teacher Preparation

The extent and nature of teacher preparation can greatly influence the quality of science instruction. Thus, the 2018 NSSME+ collected data on a number of indicators of teacher preparation, including content background, certification, and professional development experiences.

Content Background

One important aspect of teacher preparation is content knowledge. As can be seen in Table 18, large proportions of novice and veteran science teachers at the elementary and middle levels did not have a degree in science, engineering, or science education. At the high school level, 75 percent of novice science teachers had a degree in science and/or engineering (defined as an undergraduate major or graduate degree). Including science education increases the proportion with a degree in the discipline to 82 percent (some teachers had degrees in science/engineering and science education). However, novice high school science teachers were still less likely than veterans to have a science-related degree.

Table 18
Teacher Degrees

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Elementary		
Science/Engineering	4 (1.7)	2 (0.8)
Science Education	0 (0.3)	1 (0.5)
Science/Engineering or Science Education	4 (1.7)	3 (0.9)
Middle		
Science/Engineering	37 (6.1)	44 (3.1)
Science Education*	27 (4.4)	40 (3.6)
Science/Engineering or Science Education	48 (6.0)	58 (3.1)
High		
Science/Engineering*	75 (3.6)	83 (1.6)
Science Education*	33 (3.7)	64 (2.5)
Science/Engineering or Science Education*	82 (3.1)	94 (1.0)

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

Teachers 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 teachers be prepared to teach life science, Earth science, and physical science.[4] As a proxy for the competencies outlined by NSTA, teachers were asked about their coursework in each area. As can be seen in Table 19, the majority of novice and veteran elementary teachers had courses in at least 2 of the 3 areas, and about one-third had coursework in all three areas. There are no differences between novices and veterans in these coursework distributions.

Table 19
Elementary Science Teachers' Coursework Related to NSTA Preparation Standards[†]

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Courses in Earth, life, and physical science[a]	31 (3.3)	35 (1.9)
Courses in 2 of the 3 areas	40 (3.5)	35 (2.0)
Course in 1 of the 3 areas	19 (2.8)	25 (1.9)
Courses in 0 of the 3 areas	9 (2.2)	5 (1.0)

† There are no significant differences in the distribution of responses between novice and veteran teachers (Chi-square test of independence, $p \geq 0.05$).

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

Similarly, middle school teachers are expected to have expertise in multiple science disciplines. As can be seen in Table 20, the majority of novices and veterans had coursework in at least 3 of

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

the 4 areas recommended by NSTA. However, the science coursework distributions of novices and veterans were different from one another, likely because fewer novices than veterans had coursework in all four areas (33 vs. 54 percent).

Table 20
Middle School General/Integrated Science
Teachers' Coursework Related to NSTA Preparation Standards

	PERCENT OF TEACHERS*	
	NOVICE	VETERAN
Courses in chemistry, Earth science, life science, and physics	33 (4.6)	54 (2.7)
Courses in 3 of the 4 areas	41 (6.4)	25 (3.1)
Courses in 2 of the 4 areas	12 (3.0)	13 (2.2)
Course in 1 of the 4 areas	3 (1.7)	3 (1.1)
Courses in 0 of the 4 areas	10 (4.8)	5 (1.8)

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

Many secondary science classes focus on a single area of science, such as biology or Earth science. Table 21 provides information about extent to which the novices and veterans teaching these courses had a substantial background in the subject (defined as having a degree or three or more advanced courses in the area). At the middle school level, larger percentages of life science/biology teachers had a substantial background in their subject than those who taught physical science or Earth science. A similar trend is seen at the high school level, as larger percentages of life science/biology teachers had a substantial background in their subject than those who taught chemistry, physics, Earth science, or environmental science.

There were also differences in these data between novices and veterans. At both the middle and high school grade bands, novices teaching Earth science were less likely than veterans to have substantial coursework in the area (7 vs. 33 percent and 14 vs. 38 percent, respectively). In addition, differences were seen between novices and veterans at the high school level in the areas of life science/biology, chemistry, and physics. In all cases, novices were less likely than veterans to have a substantial background in their subject.

Table 21
Secondary Science Teachers With Substantial Background in Subject[a]

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Middle		
Life science/biology	72 (5.6)	59 (6.2)
Physical science	9 (4.5)	20 (6.0)
Earth science*	7 (3.2)	33 (7.6)
High		
Life science/biology*	81 (4.1)	91 (2.0)
Chemistry*	56 (5.4)	75 (2.8)
Physics*	39 (6.6)	57 (4.2)
Earth science*	14 (6.6)	38 (4.9)
Environmental science	33 (8.8)	29 (4.6)

* There is a statistically significant difference between novice and veteran teachers (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.

Certification

Another aspect of teacher preparation is certification. Data from the 2018 NSSME+ show that the most common pathway to certification for elementary and middle school science teachers was an undergraduate program leading to a bachelor's degree and a teaching credential (see Table 22). In contrast, high school teachers commonly entered the profession through a number of pathways, including an undergraduate program, a post-baccalaureate credentialing program that did not include a master's degree, and a master's program that awarded a teaching credential. However, there were differences in distribution of the data between novices and veterans at all three grade bands. At the elementary level, this difference appears to be due to more novices than veterans entering the profession through an undergraduate program leading to a bachelor's degree and a teaching credential. At the secondary level, the difference appears to be due to more novices than veterans not having earned a teaching credential, suggesting that some classes at these grade bands were being taught by individuals with emergency or temporary teaching certifications.

Table 22
Science Teachers' Paths to Certification, by Grade Range

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Elementary*		
An undergraduate program leading to a bachelor's degree and a teaching credential	75 (3.6)	62 (2.3)
A post-baccalaureate credentialing program (no master's degree awarded)	8 (2.4)	13 (2.0)
A master's program that also led to a teaching credential	15 (2.7)	25 (2.3)
Has not earned a teaching credential	3 (1.3)	0 (0.1)
Middle*		
An undergraduate program leading to a bachelor's degree and a teaching credential	54 (5.2)	52 (3.1)
A post-baccalaureate credentialing program (no master's degree awarded)	15 (3.1)	22 (3.1)
A master's program that also led to a teaching credential	21 (3.7)	25 (3.3)
Has not earned a teaching credential	10 (3.8)	1 (0.4)
High*		
An undergraduate program leading to a bachelor's degree and a teaching credential	33 (4.0)	42 (2.3)
A post-baccalaureate credentialing program (no master's degree awarded)	26 (3.4)	25 (2.0)
A master's program that also led to a teaching credential	24 (4.0)	30 (2.6)
Has not earned a teaching credential	17 (2.3)	4 (0.7)

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

At the high school level, teachers may be certified to teach in one or more areas of science. As can be seen in Table 23, the vast majority of novices and veterans were certified in at least one science area (83 and 96 percent, respectively) with the most common area being biology/life science. However, novices were less likely than veterans to be certified in the areas of biology/life science and chemistry. Not surprisingly, given the percentages who had not earned a teaching credential, novice high school science teachers were more likely than veterans to hold no science certifications (17 percent vs. 4 percent).

Table 23
High School Science Teachers' Areas of Certification

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Certified in One or More Science Areas*	83 (2.3)	96 (0.7)
Biology/life science*	62 (3.7)	74 (1.7)
Chemistry*	42 (4.0)	54 (2.5)
Earth/space science	32 (4.4)	39 (2.4)
Ecology/environmental science	31 (3.7)	33 (2.3)
Physics	29 (3.3)	35 (1.9)
Certified in All Science Areas	16 (2.8)	18 (1.6)
Not Certified in Any Science Area*	17 (2.3)	4 (0.7)

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

Teaching is not always an individual's first career. Table 24 shows the percentages of novices and veterans who had full-time job experience in a science- or engineering-related field after completing their undergraduate degree but prior to teaching. The likelihood of science teachers having prior experience increases with increasing grade band. Further, although there are no differences in prior job experience between novices and experts at the elementary and middle grade bands, novices at the high school level were more likely than veterans to have science- or engineering-related job experience prior to teaching (43 vs. 34 percent).

Table 24
Science Teachers With Full-Time Job Experience in Their Designated Field Prior to Teaching

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Elementary	6 (1.9)	2 (0.7)
Middle	19 (3.9)	25 (3.6)
High*	43 (3.9)	34 (2.5)

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

Professional Development Experiences

The 2018 NSSME+ asked teachers about opportunities they had for continued learning. As shown in Table 25, just over half of novices and veterans at the elementary level had participated in science-specific professional development in the last three years. These percentages increase with increasing grade band as 69–84 percent of secondary teachers had science-specific professional development in the last three years. However, few novices or veterans at any grade band had what might be considered substantial professional development opportunities (more than 35 hours).

There are no differences in science-focused professional development participation between novices and veterans at the elementary level. At the middle school level, novices were less likely than veterans to have had any professional development in the preceding three years (69 vs. 81 percent), perhaps due in part to the fact that some novices had not been teaching for that long. Novices at the middle school level were also less likely than veterans to have more than 35 hours of professional development (19 vs. 29 percent) in the last three years. Similarly, novice high school teachers were less likely than their veteran counterparts to have participated in more than 35 hours of professional development in the last three years (29 vs. 36 percent).

Table 25
Participation in Science-Focused
Professional Development in the Last Three Years, by Grade Range

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Elementary		
Any science-focused professional development	57 (3.8)	58 (2.7)
More than 35 hours of science-focused professional development	3 (1.1)	6 (1.0)
Middle		
Any science-focused professional development *	69 (4.4)	81 (2.4)
More than 35 hours of science-focused professional development *	19 (2.6)	29 (2.5)
High		
Any science-focused professional development	84 (3.3)	83 (1.4)
More than 35 hours of science-focused professional development *	29 (3.4)	36 (1.9)

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

Teachers who had recently participated in professional development were asked about the nature of those activities. As can be seen in Table 26, at each grade band, over 85 percent of teachers who had professional development in the preceding three years participated in professional development programs/workshops. Participation in professional learning communities was also quite common, especially for secondary teachers. Although there are no differences in professional development activities between novices and experts at the elementary level, novices at the middle and high school grade bands were significantly more likely than veterans to receive assistance or feedback from a formally designated coach or mentor (46 vs. 28 percent and 64 vs. 26 percent, respectively). However, some of this coaching/mentoring was probably in the context of an induction program and, as such, may be unlikely to continue.

Table 26
Science Teachers Participating in Various
Professional Development Activities in Last Three Years, by Grade Range

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Elementary		
Attended a professional development program/workshop	87 (3.6)	89 (2.6)
Participated in a professional learning community/lesson study/teacher study group	39 (5.1)	43 (3.4)
Received assistance or feedback from a formally designated coach/mentor	29 (5.2)	27 (3.3)
Completed an online course/webinar	13 (3.9)	8 (1.7)
Attended a national, state, or regional science teacher association meeting	8 (2.7)	13 (2.3)
Took a formal course for college credit	4 (2.2)	6 (1.4)
Middle		
Attended a professional development program/workshop	95 (2.0)	94 (1.5)
Participated in a professional learning community/lesson study/teacher study group	61 (5.8)	61 (3.4)
Received assistance or feedback from a formally designated coach/mentor*	46 (6.3)	28 (3.6)
Completed an online course/webinar	28 (4.3)	30 (3.6)
Attended a national, state, or regional science teacher association meeting	29 (4.3)	40 (4.1)
Took a formal course for college credit	13 (3.4)	7 (1.5)
High		
Attended a professional development program/workshop	86 (3.0)	92 (1.7)
Participated in a professional learning community/lesson study/teacher study group*	66 (4.1)	52 (2.2)
Received assistance or feedback from a formally designated coach/mentor*	64 (4.6)	26 (2.1)
Completed an online course/webinar	31 (3.2)	35 (2.7)
Attended a national, state, or regional science teacher association meeting	37 (4.7)	41 (2.6)
Took a formal course for college credit	17 (3.3)	16 (1.6)

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

Teachers who had recently participated in professional development were also asked about the characteristics of those experiences, specifically the extent to which they aligned with what is known about effective professional development.[5] As can be seen in Table 27, about half of teachers at each grade band had opportunities to work closely during professional development with other science teachers from their schools or science teachers in their grade level and/or subject, whether or not they were from the same school. Other relatively common professional development characteristics included experiencing lessons as students would from the textbook/modules used in the classroom and engaging in science investigations/engineering design challenges. There are no differences between novices and veterans at any of the grade bands related to the characteristics of their professional development experiences.

[5] 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 27
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	
	NOVICE	VETERAN
Elementary		
Worked closely with other teachers from their school	61 (5.6)	57 (4.0)
Worked closely with other teachers who taught the same grade and/or subject whether or not they were from their school	48 (5.4)	47 (3.9)
Had opportunities to experience lessons, as their students would, from the textbook/ modules they use in their classroom	45 (4.9)	42 (3.8)
Had opportunities to engage in science investigations/engineering design challenges	35 (5.1)	39 (3.8)
Had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction)	35 (5.3)	28 (3.2)
Had opportunities to rehearse instructional practices during the professional development (i.e., try out, receive feedback, and reflect on those practices)	29 (5.1)	20 (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	27 (5.3)	32 (3.0)
Middle		
Worked closely with other teachers from their school	69 (4.6)	59 (4.3)
Worked closely with other teachers who taught the same grade and/or subject whether or not they were from their school	56 (5.5)	52 (4.0)
Had opportunities to experience lessons, as their students would, from the textbook/ modules they use in their classroom	48 (6.3)	38 (3.7)
Had opportunities to engage in science investigations/engineering design challenges	43 (6.3)	47 (4.1)
Had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction)	33 (5.8)	40 (3.6)
Had opportunities to rehearse instructional practices during the professional development (i.e., try out, receive feedback, and reflect on those practices)	34 (5.5)	25 (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	39 (5.3)	40 (3.5)
High		
Worked closely with other teachers from their school	59 (4.2)	53 (2.5)
Worked closely with other teachers who taught the same grade and/or subject whether or not they were from their school	56 (4.1)	54 (2.4)
Had opportunities to experience lessons, as their students would, from the textbook/ modules they use in their classroom	49 (4.9)	45 (2.4)
Had opportunities to engage in science investigations/engineering design challenges	41 (4.3)	47 (2.5)
Had opportunities to examine classroom artifacts (e.g., student work samples, videos of classroom instruction)	37 (4.9)	40 (2.5)
Had opportunities to rehearse instructional practices during the professional development (i.e., try out, receive feedback, and reflect on those practices)	38 (5.5)	35 (2.6)
Had opportunities to apply what they learned to their classroom and then come back and talk about it as part of the professional development	42 (5.4)	43 (2.5)

† There are no significant differences between novice and veteran teachers (two-tailed independent samples t-test, $p \geq 0.05$).

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

The survey also asked teachers about the focus of professional development opportunities they had in the last three years, particularly the extent to which these experiences focused on student-centered instruction. As can be seen in Table 28, the most common areas of emphasis at all three grade bands were deepening teachers' understanding of how science is done; providing science instruction that integrates engineering, mathematics, and/or computer science; and monitoring student understanding during science instruction. However, the modest percentages for these items suggest that none of them were widely addressed.

Few differences in the foci of professional development opportunities are seen when comparing novices to veterans. At the elementary level, novice science teachers were more likely than veterans to have attended professional development that focused on incorporating students' cultural backgrounds into science instruction (29 vs. 16 percent). At the high school level, novices were more likely than veterans to have attended professional development that focused on differentiating science instruction to meet the needs of diverse learners (55 vs. 44 percent).

Table 28
Science Teachers Reporting That Their Professional Development in the Last Three Years Gave Heavy Emphasis[a] to Various Areas

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Elementary		
Deepening their understanding of how science is done (e.g., developing scientific questions, developing and using models, engaging in argumentation)	44 (5.3)	37 (3.6)
Learning how to provide science instruction that integrates engineering, mathematics, and/or computer science	43 (5.5)	34 (3.5)
Monitoring student understanding during science instruction	41 (5.6)	41 (3.5)
Deepening their own science content knowledge	38 (4.9)	39 (2.8)
Finding out what students think or already know prior to instruction on a topic	38 (5.2)	34 (3.3)
Differentiating science instruction to meet the needs of diverse learners	37 (4.7)	32 (3.5)
Implementing the science textbook/modules to be used in their classroom	36 (5.4)	34 (3.8)
Incorporating students' cultural backgrounds into science instruction*	29 (4.5)	16 (2.8)
Learning about difficulties that students may have with particular science ideas	25 (4.2)	28 (3.8)
Deepening their understanding of how engineering is done (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)	19 (4.9)	27 (3.5)
Middle		
Deepening their understanding of how science is done (e.g., developing scientific questions, developing and using models, engaging in argumentation)	59 (6.1)	59 (3.7)
Learning how to provide science instruction that integrates engineering, mathematics, and/or computer science	45 (6.2)	50 (4.1)
Monitoring student understanding during science instruction	50 (5.7)	47 (4.1)
Deepening their own science content knowledge	57 (6.0)	49 (4.2)
Finding out what students think or already know prior to instruction on a topic	48 (7.1)	40 (4.4)
Differentiating science instruction to meet the needs of diverse learners	57 (6.1)	46 (3.7)
Implementing the science textbook/modules to be used in their classroom	34 (5.5)	29 (3.8)
Incorporating students' cultural backgrounds into science instruction	33 (6.7)	25 (2.7)
Learning about difficulties that students may have with particular science ideas	43 (5.7)	32 (3.8)
Deepening their understanding of how engineering is done (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)	38 (6.6)	32 (3.9)
High		
Deepening their understanding of how science is done (e.g., developing scientific questions, developing and using models, engaging in argumentation)*	42 (4.3)	53 (2.6)
Learning how to provide science instruction that integrates engineering, mathematics, and/or computer science	32 (5.1)	34 (2.3)
Monitoring student understanding during science instruction	50 (4.4)	46 (2.4)
Deepening their own science content knowledge	38 (3.6)	47 (2.4)
Finding out what students think or already know prior to instruction on a topic	39 (4.1)	36 (2.2)
Differentiating science instruction to meet the needs of diverse learners*	55 (4.5)	44 (2.4)
Implementing the science textbook/modules to be used in their classroom	33 (4.2)	28 (2.2)
Incorporating students' cultural backgrounds into science instruction	30 (5.1)	21 (2.2)
Learning about difficulties that students may have with particular science ideas	46 (4.9)	39 (2.1)
Deepening their understanding of how engineering is done (e.g., identifying criteria and constraints, designing solutions, optimizing solutions)	19 (4.0)	24 (1.9)

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

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

These two sets of items were combined into two composite variables: Extent Professional Development Aligns with Elements of Effective Professional Development and Extent Professional Development Supports Student-Centered Instruction. As can be seen in Table 29, the modest composite mean scores suggest that professional development opportunities were not well aligned with elements of effective professional development and only moderately supported student-centered instruction. The mean scores on these composites were similar for novices and veterans across grade bands, indicating that professional development opportunities were relatively consistent.

Table 29
Teacher Mean Scores for Professional Development Composites†

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Elementary		
Extent Professional Development Aligns With Elements of Effective Professional Development	50 (2.7)	48 (1.7)
Extent Professional Development Supports Student-Centered Instruction	50 (2.6)	47 (1.7)
Middle		
Extent Professional Development Aligns With Elements of Effective Professional Development	57 (2.0)	54 (1.7)
Extent Professional Development Supports Student-Centered Instruction	58 (2.0)	54 (1.3)
High		
Extent Professional Development Aligns With Elements of Effective Professional Development	55 (2.2)	55 (1.1)
Extent Professional Development Supports Student-Centered Instruction	52 (2.0)	52 (0.9)

† There are no significant differences between novice and veteran teachers (two-tailed independent samples t-test, $p \geq 0.05$).

Teacher Beliefs and Perceptions of Preparedness

Teachers' beliefs about effective instruction and perceptions of preparedness to teach science are a result of many factors, including their own experiences learning science, their pre-service education coursework, and their ongoing professional learning opportunities. Because beliefs and feelings of preparedness influence instruction, the 2018 NSSME+ asked teachers about their beliefs about effective science instruction, their feelings of preparedness to teach the science content they are expected to cover, and their pedagogical preparedness.

Teacher Beliefs

Teachers were asked about their beliefs regarding effective teaching and learning. As can be seen in Tables 30–32, the survey revealed a number of areas in which science teachers' beliefs were aligned with current thinking about effective science instruction.[6] For example, more than 90 percent of novices and veterans at each grade band agreed that teachers should ask students to support their conclusions about a science concept with evidence, students should learn science by doing science, and that students learn best when instruction is connected to their everyday lives.

Few differences in teacher beliefs about effective teaching and learning emerged when comparing novices to veterans. At the elementary level, novices were less likely than veterans to agree that it is better for science instruction to focus on ideas in depth, even if that means covering fewer topics (68 vs. 78 percent). However, at the high school level, novices were more likely than veterans to agree that most class periods should provide opportunities for students to share their thinking and reasoning (94 vs. 88 percent).

In other areas, science teachers' beliefs were inconsistent with what is known from research on learning. For example, more than two-thirds of novices and veterans at each grade band agreed that students should be provided with definitions for new scientific vocabulary at the beginning of instruction on a science idea. Additionally, 49–69 percent of teachers agreed that hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned.

Novices at all three grade bands were more likely to hold traditional beliefs than their veteran counterparts. At the elementary level, 43 percent of novices agreed that teachers should explain an idea to students before having them consider evidence that relates to the idea, compared to 29 percent of veterans. At the middle and high school level, novices were more likely than veterans to agree that at the beginning of instruction on a science idea, that students should be provided with definitions for new scientific vocabulary (81 vs. 68 percent and 74 vs. 64 percent, respectively) and that hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned (69 vs. 50 percent and 63 vs. 49 percent, respectively).

[6] National Research Council. 2005. How Students Learn: Science in the Classroom. Washington, DC: The National Academies Press.

Table 30
Elementary Science Teachers Agreeing[a] With Various Statements About Teaching and Learning

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Reform-Oriented Beliefs		
Teachers should ask students to support their conclusions about a science concept with evidence.	96 (1.5)	94 (1.4)
Most class periods should provide opportunities for students to share their thinking and reasoning.	95 (1.8)	96 (0.9)
Students should learn science by doing science (e.g., developing scientific questions; designing and conducting investigations; analyzing data; developing models, explanations, and scientific arguments).	95 (1.7)	95 (1.2)
Students learn best when instruction is connected to their everyday lives.	94 (2.0)	96 (1.1)
Most class periods should provide opportunities for students to apply scientific ideas to real-world contexts.	92 (2.4)	94 (1.4)
It is better for science instruction to focus on ideas in depth, even if that means covering fewer topics.*	68 (3.9)	78 (2.3)
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.	81 (2.6)	75 (2.6)
Hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned.	60 (4.7)	54 (2.9)
Teachers should explain an idea to students before having them consider evidence that relates to the idea.*	43 (3.8)	29 (2.4)
Students learn science best in classes with students of similar abilities.	27 (3.7)	24 (2.1)

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

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

Table 31
Middle School Science Teachers Agreeing[a] With Various Statements About Teaching and Learning

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Reform-Oriented Beliefs		
Students learn best when instruction is connected to their everyday lives.	97 (1.4)	97 (0.9)
Teachers should ask students to support their conclusions about a science concept with evidence.	96 (2.4)	97 (0.9)
Students should learn science by doing science (e.g., developing scientific questions; designing and conducting investigations; analyzing data; developing models, explanations, and scientific arguments).	96 (1.4)	91 (2.6)
Most class periods should provide opportunities for students to apply scientific ideas to real-world contexts.	93 (2.6)	89 (2.7)
Most class periods should provide opportunities for students to share their thinking and reasoning.	92 (3.2)	93 (2.7)
It is better for science instruction to focus on ideas in depth, even if that means covering fewer topics.	76 (4.4)	73 (3.7)
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.*	81 (3.4)	68 (3.0)
Hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned.*	69 (4.3)	50 (3.2)
Students learn science best in classes with students of similar abilities.	49 (5.8)	47 (4.6)
Teachers should explain an idea to students before having them consider evidence that relates to the idea.	38 (5.6)	26 (2.9)

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

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

Table 32
High School Science Teachers Agreeing[a] With
Various Statements About Teaching and Learning

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Reform-Oriented Beliefs		
Teachers should ask students to support their conclusions about a science concept with evidence.	99 (0.4)	99 (0.4)
Students learn best when instruction is connected to their everyday lives.	96 (1.5)	96 (0.9)
Students should learn science by doing science (e.g., developing scientific questions; designing and conducting investigations; analyzing data; developing models, explanations, and scientific arguments).	95 (1.6)	93 (1.6)
Most class periods should provide opportunities for students to share their thinking and reasoning.*	94 (2.0)	88 (1.7)
Most class periods should provide opportunities for students to apply scientific ideas to real-world contexts.	93 (2.0)	90 (1.7)
It is better for science instruction to focus on ideas in depth, even if that means covering fewer topics.	75 (4.0)	77 (2.3)
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.*	74 (4.0)	64 (2.4)
Hands-on/laboratory activities should be used primarily to reinforce a science idea that the students have already learned.*	63 (4.2)	49 (2.4)
Students learn science best in classes with students of similar abilities.	55 (4.1)	62 (1.9)
Teachers should explain an idea to students before having them consider evidence that relates to the idea.	39 (4.0)	36 (2.6)

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

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

The belief items were combined into two composite variables: Reform-Oriented Teaching Beliefs and Traditional Teaching Beliefs. The mean scores shown in Table 33 suggest that elementary, middle, and high school science teachers had relatively strong reform-oriented beliefs. However, traditional beliefs were also fairly prevalent across all grades. Further, novices were significantly more likely than veterans at all three grade bands to hold traditional beliefs about teaching and learning.

Table 33
Mean Scores for Science Teachers' Beliefs About Teaching and Learning Composites

	MEAN SCORE	
	NOVICE	VETERAN
Elementary		
Reform-Oriented Beliefs	87 (1.2)	86 (0.7)
Traditional Beliefs*	59 (1.5)	54 (1.0)
Middle		
Reform-Oriented Beliefs	87 (1.3)	86 (1.0)
Traditional Beliefs*	62 (1.8)	55 (1.3)
High		
Reform-Oriented Beliefs*	88 (0.9)	84 (0.7)
Traditional Beliefs*	62 (1.7)	58 (0.8)

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

Teacher Perceptions of Content Preparedness

Elementary teachers are typically assigned to teach multiple subjects to a single group of students. However, only 29 percent of novices and veterans at this grade level felt very well prepared to teach science (see Table 34). In contrast, more than two-thirds of teachers perceived themselves to be very well prepared to teach reading/language arts and mathematics.

Table 34
Self-Contained Elementary Teachers'
Perceptions of Their Preparedness to Teach Each Subject

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Reading/Language arts*		
Not adequately prepared	0 (0.2)	0 (0.2)
Somewhat prepared	6 (1.4)	2 (0.5)
Fairly well prepared	27 (2.2)	17 (1.3)
Very well prepared	68 (2.6)	80 (1.3)
Mathematics		
Not adequately prepared	0 (0.4)	0 (0.0)
Somewhat prepared	5 (1.5)	4 (0.9)
Fairly well prepared	27 (3.8)	21 (2.0)
Very well prepared	68 (3.9)	75 (2.0)
Social studies*		
Not adequately prepared	5 (1.2)	2 (0.4)
Somewhat prepared	19 (2.3)	14 (1.1)
Fairly well prepared	41 (2.7)	39 (1.5)
Very well prepared	35 (2.2)	45 (1.6)
Science		
Not adequately prepared	6 (2.1)	4 (0.8)
Somewhat prepared	22 (3.2)	22 (1.8)
Fairly well prepared	43 (3.7)	42 (2.3)
Very well prepared	29 (3.5)	29 (3.5)
Computer science/programming		
Not adequately prepared	46 (3.6)	46 (2.0)
Somewhat prepared	37 (2.9)	34 (1.8)
Fairly well prepared	12 (1.6)	14 (1.2)
Very well prepared	5 (1.1)	6 (0.8)

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

As can be seen in Table 35, few elementary teachers felt very well prepared to teach any science discipline. Engineering stands out as the area where elementary teachers felt least prepared, as about half were not adequately prepared to teach engineering. Comparing novices to veterans, there is a significant difference in the distribution of responses for the disciplines of life science and physical science. These data suggest that novices felt less prepared than veterans to teach in either of these disciplines.

Table 35
Elementary Teachers' Perceptions of Their Preparedness to Teach Various Science Disciplines

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Life science*		
Not adequately prepared	6 (1.7)	3 (0.8)
Somewhat prepared	29 (3.9)	21 (2.0)
Fairly well prepared	46 (3.8)	50 (2.1)
Very well prepared	19 (2.8)	26 (2.0)
Earth/Space science		
Not adequately prepared	8 (2.0)	5 (1.0)
Somewhat prepared	30 (3.6)	25 (1.7)
Fairly well prepared	44 (4.0)	49 (1.8)
Very well prepared	18 (2.4)	21 (1.7)
Physical science*		
Not adequately prepared	17 (2.5)	9 (1.5)
Somewhat prepared	34 (3.1)	34 (1.9)
Fairly well prepared	38 (4.1)	42 (2.3)
Very well prepared	10 (2.0)	15 (1.3)
Engineering		
Not adequately prepared	55 (3.9)	49 (2.5)
Somewhat prepared	29 (3.1)	33 (1.9)
Fairly well prepared	14 (2.3)	14 (1.5)
Very well prepared	2 (1.1)	3 (0.9)

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

The survey presented middle and high school science teachers with a list of topics based on the subject of a randomly selected class in their teaching assignment, 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 36, modest percentages of middle school teachers felt very well prepared to teach any topic in any discipline. In contrast, high school science teachers across disciplines generally felt confident in their preparedness to teach various topics (see Table 37). However, at both grade bands, novices were significantly less likely than veterans to consider themselves very well prepared to teach a number of science topics. For example, novice middle school teachers were less likely than veterans to feel very well prepared to teach about forces and motion (27 vs. 51 percent); energy transfers, transformations, and conservation (23 vs. 47 percent); and properties and behaviors of waves (14 vs. 24 percent). Similarly, novice high school physics teachers were less likely than veterans to feel very well prepared to teach about energy transfers, transformations, and conservation (54 vs. 81 percent); properties and behaviors of waves (34 vs. 68 percent); electricity and magnetism (23 vs. 55 percent); and modern physics (11 vs. 23 percent).

Table 36
Middle School Science Teachers Considering Themselves Very Well Prepared to Teach Each of a Number of Topics

	PERCENT OF TEACHERS[a]	
	NOVICE	VETERAN
Earth/Space Science		
Earth's features and physical processes*	29 (3.7)	49 (3.1)
The solar system and the universe*	24 (3.5)	36 (2.9)
Climate and weather*	22 (3.5)	35 (3.1)
Biology/Life Science		
Structures and functions of organisms	47 (6.1)	59 (3.7)
Ecology/ecosystems	46 (5.4)	54 (4.1)
Cell biology*	40 (5.7)	56 (3.3)
Genetics	40 (5.5)	49 (3.8)
Evolution	38 (5.1)	41 (3.6)
Chemistry		
States, classes, and properties of matter*	38 (5.6)	63 (3.4)
The periodic table*	33 (5.9)	53 (3.5)
Elements, compounds, and mixtures*	32 (5.6)	50 (3.3)
Atomic structure*	31 (5.7)	52 (3.5)
Properties of solutions*	22 (4.6)	34 (2.6)
Chemical bonding, equations, nomenclature, and reactions	22 (4.9)	32 (3.0)
Physics		
Forces and motion*	27 (5.1)	51 (3.8)
Energy transfers, transformations, and conservation*	23 (4.4)	47 (3.7)
Properties and behaviors of waves*	14 (3.3)	24 (2.9)
Electricity and magnetism	14 (3.3)	21 (2.6)
Modern physics	8 (2.8)	7 (1.3)
Environmental and Resource Issues (e.g., land and water use, energy resources and consumption, sources and impacts of pollution)	38 (6.0)	29 (3.4)

* There is a statistically significant difference between novice and veteran teachers (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 his/her randomly selected class.

Table 37
High School Science Teachers Considering Themselves
Very Well Prepared to Teach Each of a Number of Topics, by Grade Range

	PERCENT OF TEACHERS[a]	
	NOVICE	VETERAN
Earth/Space Science		
The solar system and the universe	47 (16.8)	60 (7.7)
Earth's features and physical processes*	44 (16.2)	67 (7.8)
Climate and weather	40 (15.1)	63 (8.0)
Biology/Life Science		
Cell biology*	57 (5.0)	77 (2.9)
Genetics*	53 (6.2)	74 (3.4)
Structures and functions of organisms*	49 (5.5)	76 (3.3)
Evolution*	49 (5.6)	66 (3.3)
Ecology/ecosystems*	42 (6.8)	72 (3.2)
Chemistry		
Atomic structure	78 (8.9)	90 (2.7)
States, classes, and properties of matter	76 (9.1)	91 (1.5)
Elements, compounds, and mixtures	75 (9.3)	93 (1.6)
The periodic table	75 (9.4)	93 (1.5)
Chemical bonding, equations, nomenclature, and reactions*	69 (8.6)	89 (2.9)
Properties of solutions*	56 (7.1)	80 (3.1)
Physics		
Forces and motion	61 (11.5)	84 (4.1)
Energy transfers, transformations, and conservation*	54 (10.5)	81 (4.5)
Properties and behaviors of waves*	34 (7.4)	68 (4.9)
Electricity and magnetism*	23 (7.0)	55 (5.0)
Modern physics*	11 (4.9)	23 (2.9)
Environmental and Resource Issues (e.g., land and water use, energy resources and consumption, sources and impacts of pollution)	54 (16.8)	62 (8.9)

* There is a statistically significant difference between novice and veteran teachers (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 his/her randomly selected class.

Table 38 displays mean scores for the Perceptions of Content Preparedness composite variable, which was created from these items. The mean scores indicate that elementary teachers generally did not feel well prepared to teach science. Further, novices at all three grade bands felt less well prepared to teach science content than their veteran counterparts.

Table 38
Mean Scores for Science Teachers' Perceptions of Content Preparedness Composite

	MEAN SCORE	
	NOVICE	VETERAN
Elementary*	46 (1.4)	51 (0.9)
Middle*	64 (1.8)	74 (0.9)
High*	81 (1.5)	90 (0.6)

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

Secondary science teachers were also asked about their preparedness to teach engineering. As can be seen in Tables 39–40, very few middle or high school teachers felt very well prepared to teacher engineering concepts, and sizeable proportions were not adequately prepared to do so. There are no differences between novices and veterans at either grade band in their perceptions of preparedness to teach engineering.

Table 39
Middle School Science Teachers' Perceptions of Their Preparedness to Teach Engineering†

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Developing possible solutions		
Not Adequately Prepared	32 (4.5)	26 (2.3)
Somewhat Prepared	33 (4.2)	31 (2.4)
Fairly Well Prepared	24 (3.6)	27 (2.8)
Very Well Prepared	10 (2.3)	16 (2.4)
Defining engineering problems		
Not Adequately Prepared	33 (4.0)	28 (2.4)
Somewhat Prepared	38 (4.0)	33 (2.8)
Fairly Well Prepared	20 (3.2)	26 (2.8)
Very Well Prepared	10 (2.1)	13 (2.2)
Optimizing a design solution		
Not Adequately Prepared	38 (4.7)	30 (2.4)
Somewhat Prepared	30 (3.9)	34 (2.5)
Fairly Well Prepared	23 (3.6)	25 (2.5)
Very Well Prepared	8 (2.0)	11 (2.1)

† There are no significant differences in the distribution of responses between novice and veteran teachers (Chi-square test of independence, $p \geq 0.05$).

Table 40
High School Science Teachers' Perceptions of Their Preparedness to Teach Engineering†

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Developing possible solutions		
Not Adequately Prepared	36 (3.1)	33 (2.1)
Somewhat Prepared	30 (2.9)	38 (2.1)
Fairly Well Prepared	25 (2.9)	22 (1.5)
Very Well Prepared	9 (1.9)	8 (0.9)
Defining engineering problems		
Not Adequately Prepared	39 (3.4)	36 (1.9)
Somewhat Prepared	39 (3.3)	38 (1.9)
Fairly Well Prepared	16 (2.6)	19 (1.3)
Very Well Prepared	6 (1.1)	7 (0.8)
Optimizing a design solution		
Not Adequately Prepared	45 (3.5)	40 (2.1)
Somewhat Prepared	32 (3.4)	38 (2.0)
Fairly Well Prepared	17 (2.3)	17 (1.2)
Very Well Prepared	5 (1.2)	6 (0.8)

† There are no significant differences in the distribution of responses between novice and veteran teachers (Chi-square test of independence, $p \geq 0.05$).

The relatively low scores on the Perceptions of Preparedness to Teach Engineering composite, shown in Table 41, also highlight the fact that middle and high school science teachers did not feel adequately prepared to teach engineering. There are no significant differences between novice and veteran teachers on this composite at either grade level.

Table 41
Mean Scores for Secondary Science Teachers' Perceptions of Preparedness to Teach Engineering Composite†

	MEAN SCORE	
	NOVICE	VETERAN
Middle	40 (2.6)	45 (1.8)
High	32 (1.9)	33 (1.0)

† There are no significant differences between novice and veteran teachers (two-tailed independent samples t-test, $p \geq 0.05$).

Teacher Perceptions of Pedagogical Preparedness

Two sets of survey items focused on teacher preparedness for a number of tasks associated with science instruction. A first set of items asked teachers how well prepared they felt to carry out a number of instructional tasks. Although teacher preparedness to carry out these tasks was rather low across grade bands, it did tend to increase with increasing grade band (see Table 42). Notably, one-quarter or fewer teachers at each grade band felt very well prepared to provide science instruction based on students' ideas, incorporate students' cultural backgrounds into science instruction, or develop students' awareness of STEM careers.

There are no differences on these items between novice and veteran teachers at the elementary level. However, at the middle and high school levels, novices were less likely than veterans to feel very well prepared to use formative assessment to monitor student learning (39 vs. 53 percent and 42 vs. 55 percent, respectively), differentiate science instruction to meet the needs of diverse learners (25 vs. 37 percent and 28 vs. 37 percent, respectively), develop students' conceptual understanding (28 vs. 48 percent and 40 vs. 63 percent, respectively), and develop students' abilities to do science (28 vs. 44 percent and 31 vs. 51 percent, respectively). In addition, novice high school teachers were less likely than veterans to feel very well prepared to encourage participation of all students in science and/or engineering (32 vs. 46 percent) and encourage students' interest in science and/or engineering (37 vs. 46 percent). These data suggest that novice science teachers need further preparation in tailoring instruction to meet the needs of all learners.

Table 42
Science Teachers Considering Themselves Very Well Prepared for Each of a Number of Tasks

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Elementary		
Encourage participation of all students in science and/or engineering	31 (1.6)	30 (3.4)
Use formative assessment to monitor student learning	31 (3.7)	27 (1.8)
Encourage students' interest in science and/or engineering	26 (3.0)	26 (1.5)
Differentiate science instruction to meet the needs of diverse learners	20 (2.4)	19 (1.5)
Develop students' conceptual understanding	19 (2.7)	24 (1.8)
Develop students' abilities to do science (e.g., develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)	15 (2.2)	18 (1.8)
Provide science instruction that is based on students' ideas	13 (2.2)	12 (1.3)
Incorporate students' cultural backgrounds into science instruction	13 (1.9)	10 (1.3)
Develop students' awareness of STEM careers	11 (2.2)	9 (1.2)
Middle		
Encourage participation of all students in science and/or engineering	39 (4.5)	47 (2.8)
Use formative assessment to monitor student learning*	39 (4.1)	53 (2.9)
Encourage students' interest in science and/or engineering	37 (4.4)	44 (2.8)
Differentiate science instruction to meet the needs of diverse learners*	25 (3.7)	37 (2.6)
Develop students' conceptual understanding*	28 (4.1)	48 (2.8)
Develop students' abilities to do science (e.g., develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)*	28 (3.2)	44 (2.7)
Provide science instruction that is based on students' ideas	21 (3.0)	21 (2.1)
Incorporate students' cultural backgrounds into science instruction	16 (2.7)	15 (1.6)
Develop students' awareness of STEM careers	21 (3.7)	21 (2.2)
High		
Encourage participation of all students in science and/or engineering*	32 (2.6)	46 (1.9)
Use formative assessment to monitor student learning*	42 (3.3)	55 (2.1)
Encourage students' interest in science and/or engineering*	37 (2.5)	46 (1.9)
Differentiate science instruction to meet the needs of diverse learners*	28 (2.7)	37 (1.9)
Develop students' conceptual understanding *	40 (2.7)	63 (2.0)
Develop students' abilities to do science (e.g., develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)*	31 (3.0)	51 (1.9)
Provide science instruction that is based on students' ideas	21 (2.4)	25 (1.5)
Incorporate students' cultural backgrounds into science instruction	19 (2.4)	17 (1.5)
Develop students' awareness of STEM careers	24 (2.5)	20 (1.5)

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

These items were combined into a composite variable to examine science teachers' overall perceptions of pedagogical preparedness (see Table 43). The mean scores indicate that novices and veterans at the elementary and middle school levels held similar perceptions of pedagogical preparedness. However, novice high school teachers were significantly less likely to feel prepared than veterans (mean scores of 66 vs. 72).

Table 43
Mean Scores for Science Teachers' Perceptions of Pedagogical Preparedness Composite

	MEAN SCORE	
	NOVICE	VETERAN
Elementary	58 (1.4)	57 (0.9)
Middle	66 (1.6)	69 (1.2)
High*	66 (1.1)	72 (0.7)

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

A second set of survey items asked teachers how well prepared they felt to monitor and address student understanding, focusing on a specific unit in a randomly selected class. As can be seen in Table 44, most novice teachers across grade bands did not feel very well prepared in these areas, including monitoring and assessing student understanding and anticipating difficulties students may have with science ideas and procedures. Further, novices at each grade band felt less prepared in these areas than veterans. This lack of preparedness is particularly concerning given that these tasks are critical components of high-quality science teaching.

Table 44
Science Classes in Which Teachers Feel Very Well Prepared for Various Tasks in the Most Recent Unit, by Grade Range

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Elementary		
Find out what students thought or already knew about the key science ideas	27 (3.4)	33 (2.7)
Monitor student understanding during this unit*	26 (3.1)	35 (2.3)
Assess student understanding at the conclusion of this unit*	26 (3.0)	34 (2.2)
Implement the instructional materials to be used during this unit*	24 (3.4)	35 (2.5)
Anticipate difficulties that students may have with particular science ideas and procedures in this unit*	15 (2.8)	25 (2.2)
Middle		
Find out what students thought or already knew about the key science ideas	34 (4.0)	41 (2.4)
Monitor student understanding during this unit*	43 (4.8)	55 (2.4)
Assess student understanding at the conclusion of this unit*	50 (4.6)	62 (2.2)
Implement the instructional materials to be used during this unit*	32 (4.1)	50 (2.7)
Anticipate difficulties that students may have with particular science ideas and procedures in this unit*	26 (3.7)	41 (2.7)
High		
Find out what students thought or already knew about the key science ideas*	27 (3.1)	41 (2.0)
Monitor student understanding during this unit*	39 (3.6)	57 (2.2)
Assess student understanding at the conclusion of this unit*	49 (3.2)	62 (2.2)
Implement the instructional materials to be used during this unit*	38 (3.1)	57 (2.0)
Anticipate difficulties that students may have with particular science ideas and procedures in this unit*	28 (2.7)	49 (1.9)

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

These items were combined to create a composite variable named Perceptions of Preparedness to Implement Instruction in Particular Unit. As can be seen in Table 45, novices at the elementary, middle, and high school levels considered themselves less well prepared than veterans in this area.

Table 45
Mean Scores for Science Teachers' Perceptions of
Preparedness to Implement Instruction in Particular Unit Composite

	MEAN SCORE	
	NOVICE	VETERAN
Elementary*	64 (1.5)	70 (1.0)
Middle*	71 (1.9)	79 (1.0)
High*	73 (1.1)	82 (0.6)

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

Instruction

The 2018 NSSME+ included several sets of items about science instruction. As can be seen in Table 46, few elementary grades classes received science instruction all or most days of the school year. In grades K–3, less than 20 percent of classes received science instruction all or most days, every week of the school year. Although grades 4–6 classes were more likely to receive science instruction all/most days, every week of the school year (ranging from 34 to 39 percent), large proportions of classes received science instruction only some days each week or some weeks of the school year.

Table 46
Frequency With Which Self-Contained
Elementary Classes Receive Science Instruction†

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Grades K–3		
All/Most days, every week	19 (2.9)	16 (1.7)
Three or fewer days, every week	40 (3.3)	40 (2.1)
Some weeks, but not every week	40 (3.8)	44 (2.1)
Grades 4–6		
All/Most days, every week	39 (5.0)	34 (3.6)
Three or fewer days, every week	37 (5.2)	35 (3.6)
Some weeks, but not every week	24 (4.3)	31 (2.7)

† There is not a significant difference in the distribution of responses between novice and veteran teachers (Chi-square test of independence, $p \geq 0.05$).

The survey also asked elementary teachers in self-contained classrooms to indicate how much time was spent on each core subject (see Table 47). Elementary classes taught by novices and veterans spent relatively little time on science compared to reading/language arts and mathematics. Additionally, teachers of grades K–3 classes appeared to spend less time on science than teachers of grades 4–6.

Table 47
Average Number of Minutes Per Day Teachers Spend
Teaching Each Subject in Self-Contained Classes,[a] by Grade Range

	NUMBER OF MINUTES	
	NOVICE	VETERAN
Grades K–3		
Reading/Language Arts*	83 (2.9)	92 (1.9)
Mathematics	56 (1.5)	57 (1.0)
Science	17 (0.8)	18 (0.6)
Social Studies	15 (0.7)	16 (0.5)
Grades 4–6		
Reading/Language Arts	85 (4.2)	81 (2.7)
Mathematics	67 (2.9)	61 (1.9)
Science	27 (1.5)	26 (1.1)
Social Studies	23 (1.4)	20 (1.0)

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

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

Research shows that ongoing support is extremely important for developing and retaining novice teachers.[7] One means of supporting novices is by providing them with fewer course preparations, which affords extra time for preparation and reflection. The NSSME+ asked secondary teachers to list each science course they taught (e.g., life science/biology, chemistry) and the level of the course (i.e., non-college prep, 1st year college prep including honors, 2nd year advanced). These data were used to compute the number of different science preparations secondary science teachers had. (The survey did not collect data on non-science courses that might also be taught by science teachers.) As can be seen in Table 48, about three-quarters of novice and veteran science teachers at the middle school level were responsible for only one type of science course (e.g., life science, 7th grade science). Although the data were more varied at the high school level, the vast majority of high school science teachers were also responsible for either one or two types of science courses. These data suggest that novices at the secondary level are generally not responsible for an excessive number of preparations.

[7] Podolsky, A., Kini, T., Bishop, J., and Darling-Hammond, L. (2016). *Solving the teacher shortage: How to attract and retain excellent educators*. Palo Alto, CA: Learning Policy Institute

Table 48
Number of Preparations of Secondary Science Teachers†

	PERCENT OF TEACHERS	
	NOVICE	VETERAN
Middle		
1	71 (4.5)	77 (2.5)
2	15 (3.2)	14 (1.7)
3	11 (4.1)	8 (2.5)
4 or more	3 (1.6)	2 (1.2)
High		
1	35 (3.6)	25 (1.8)
2	42 (3.6)	50 (2.0)
3	16 (3.0)	18 (1.3)
4 or more	7 (2.0)	6 (1.1)

† There is not a significant difference in the distribution of responses between novice and veteran teachers (Chi-square test of independence, $p \geq 0.05$).

Teacher Perceptions of Their Decision-Making Autonomy

The survey asked several series of items about the nature of science instruction, including teachers' perceptions of autonomy in making decisions about curriculum and instruction, instructional objectives, class activities, and homework. Teachers across grade bands were generally more likely to perceive themselves as having strong control over pedagogical decisions than curriculum decisions (see Table 49). For example, in elementary classes, 60 percent of novices and 62 percent of veterans perceived themselves as having strong control in determining the amount of homework to be assigned. At the secondary level, over half of classes were taught by novices and veterans perceiving themselves as having strong control in determining the amount of homework to be assigned, selecting teaching techniques, and choosing criteria for grading student performance. In far fewer classes, science teachers perceived themselves as having strong control over selecting textbooks/modules and selecting content, topics, and skills to be taught.

Table 49
Science Classes in Which Teachers Report Having Strong Control Over Various Curricular and Instructional Decisions, by Grade Range

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Elementary		
Determining the amount of homework to be assigned	62 (4.1)	60 (3.0)
Selecting teaching techniques	45 (3.5)	50 (3.1)
Choosing criteria for grading student performance	42 (4.4)	42 (3.2)
Selecting the sequence in which topics are covered	29 (4.2)	31 (3.5)
Determining the amount of instructional time to spend on each topic	22 (3.3)	21 (3.5)
Determining course goals and objectives	14 (2.5)	19 (3.5)
Selecting curriculum materials (e.g., textbooks/modules)*	9 (2.4)	18 (3.4)
Selecting content, topics, and skills to be taught*	8 (1.9)	15 (3.5)
Middle		
Determining the amount of homework to be assigned	76 (3.1)	72 (3.3)
Selecting teaching techniques	61 (4.1)	69 (2.5)
Choosing criteria for grading student performance	55 (4.2)	60 (3.2)
Selecting the sequence in which topics are covered	37 (5.2)	43 (3.5)
Determining the amount of instructional time to spend on each topic	45 (5.1)	42 (3.8)
Determining course goals and objectives	32 (5.4)	33 (3.5)
Selecting curriculum materials (e.g., textbooks/modules)	25 (5.0)	30 (3.5)
Selecting content, topics, and skills to be taught	23 (5.2)	29 (3.6)
High		
Determining the amount of homework to be assigned	74 (3.2)	74 (2.2)
Selecting teaching techniques	67 (3.6)	69 (2.9)
Choosing criteria for grading student performance	51 (4.4)	55 (2.7)
Selecting the sequence in which topics are covered	46 (4.3)	53 (2.6)
Determining the amount of instructional time to spend on each topic	48 (4.0)	49 (2.4)
Determining course goals and objectives	40 (5.0)	35 (2.5)
Selecting curriculum materials (e.g., textbooks/modules)	32 (4.3)	37 (2.5)
Selecting content, topics, and skills to be taught	36 (4.6)	34 (2.3)

* There is a statistically significant difference between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p < 0.05$).

Several of these items were combined into two composite variables: Curriculum Control and Pedagogy Control. As can be seen in Table 50, teachers at all three grade bands appeared to perceive more control over decisions related to pedagogy than curriculum. However, there are no differences in perceptions of control when comparing novices to veterans.

Table 50
Class Mean Scores for Curriculum Control and Pedagogy Control Composites†

	MEAN SCORE	
	NOVICE	VETERAN
Elementary		
Curriculum Control	42 (2.2)	47 (2.6)
Pedagogy Control	78 (1.9)	80 (1.3)
Middle		
Curriculum Control	56 (3.4)	58 (2.5)
Pedagogy Control	87 (1.3)	88 (1.4)
High		
Curriculum Control	65 (2.4)	68 (1.6)
Pedagogy Control	85 (1.6)	87 (1.3)

† There are no significant differences between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p \geq 0.05$).

Instructional Objectives

Teachers were provided a list of possible instructional objectives and asked how much emphasis each would receive over the entire course of a randomly selected class. As can be seen in Table 51, understanding science concepts was heavily emphasized in classes taught by novices and veterans in each grade band, but particularly at the middle and high school levels, where it was emphasized in roughly 75 percent of classes. In contrast, classes at all three grade bands were unlikely to heavily emphasize learning how to do science or engineering, learning about different fields of science/engineering, and developing students' confidence that they can successfully pursue careers in science/engineering.

There were very few differences between classes taught by novices and those taught by veterans. At the middle grade band, classes taught by novices were less likely than classes taught by veterans to have a heavy emphasis on learning how to do science (38 vs. 49 percent). However, at the high school level, classes taught by novices were more likely than classes taught by veterans to heavily emphasize learning science vocabulary and/or facts (37 vs. 30 percent) and increasing students' interest in science/engineering (37 vs. 29 percent).

Table 51
Science Classes Taught by Teachers With
Heavy Emphasis on Various Instructional Objectives, by Grade Range

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Elementary		
Understanding science concepts	48 (3.5)	47 (2.6)
Learning science vocabulary and/or facts	27 (3.1)	27 (2.3)
Increasing students' interest in science/engineering	25 (3.0)	28 (2.8)
Learning how to do science (develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)	25 (3.3)	28 (2.7)
Learning test-taking skills/strategies	21 (2.5)	19 (1.8)
Learning about real-life applications of science/engineering	20 (3.2)	20 (2.7)
Developing students' confidence that they can successfully pursue careers in science/ engineering	19 (2.7)	24 (2.6)
Learning about different fields of science/engineering	9 (1.9)	8 (2.6)
Learning how to do engineering (e.g., identify criteria and constraints, design solutions, optimize solutions)	6 (1.6)	9 (2.6)
Middle		
Understanding science concepts	73 (4.1)	78 (1.8)
Learning science vocabulary and/or facts	39 (3.8)	36 (2.6)
Increasing students' interest in science/engineering	40 (4.3)	33 (2.5)
Learning how to do science (develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)*	38 (3.8)	49 (2.6)
Learning test-taking skills/strategies	24 (3.0)	22 (2.4)
Learning about real-life applications of science/engineering	31 (3.6)	27 (2.2)
Developing students' confidence that they can successfully pursue careers in science/ engineering	29 (1.9)	29 (2.3)
Learning about different fields of science/engineering	11 (3.3)	5 (1.1)
Learning how to do engineering (e.g., identify criteria and constraints, design solutions, optimize solutions)	12 (2.8)	9 (1.4)
High		
Understanding science concepts	77 (2.4)	75 (2.1)
Learning science vocabulary and/or facts*	37 (3.3)	30 (1.8)
Increasing students' interest in science/engineering*	37 (3.3)	29 (1.6)
Learning how to do science (develop scientific questions; design and conduct investigations; analyze data; develop models, explanations, and scientific arguments)	39 (3.2)	42 (1.8)
Learning test-taking skills/strategies	23 (2.7)	23 (1.6)
Learning about real-life applications of science/engineering	33 (3.6)	28 (1.7)
Developing students' confidence that they can successfully pursue careers in science/ engineering	31 (3.5)	36 (1.9)
Learning about different fields of science/engineering	7 (1.5)	7 (0.9)
Learning how to do engineering (e.g., identify criteria and constraints, design solutions, optimize solutions)	4 (1.5)	5 (0.8)

* There is a statistically significant difference between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p < 0.05$).

These items related to reform-oriented instruction were combined into a composite variable (see Table 52). Overall, scores on this composite were not very high, indicating that science classes are only somewhat likely to emphasize reform-oriented instructional objectives. There are no significant differences between novices and veterans at any of the grade bands.

Table 52
Class Mean Scores for the Reform-Oriented Instructional Objectives Composite†

	MEAN SCORE	
	NOVICE	VETERAN
Elementary	61 (1.2)	60 (1.3)
Middle	67 (1.3)	66 (1.0)
High	65 (1.0)	65 (0.6)

† There are no significant differences between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p \geq 0.05$).

Class Activities

Teachers were given a list of activities and asked how often they did each in a randomly selected class. Table 53 shows the percentage of classes in which various activities were used at least once a week. Over 70 percent of classes at each grade band included whole class discussions, the teacher explaining science ideas to the whole class, and students working in small groups. However, there were also some differences between classes taught by novices and those taught by veterans. At the elementary level, novices were less likely than veterans to engage the class in project-based learning activities (24 vs. 32 percent) but more likely to use flipped instruction (14 vs. 8 percent). At the middle and high school levels, novices were less likely than veterans to have students do hands-on/laboratory activities (52 vs. 68 percent and 57 vs. 71 percent, respectively).

Table 53
Science Classes in Which Teachers Report Using Various Activities at Least Once a Week, by Grade Range

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Elementary		
Engage the whole class in discussions	88 (2.2)	91 (1.2)
Explain science ideas to the whole class	86 (2.1)	85 (2.7)
Have students work in small groups	73 (3.1)	76 (1.9)
Focus on literacy skills (e.g., informational reading or writing strategies)	55 (3.5)	62 (2.2)
Have students do hands-on/laboratory activities	51 (3.9)	54 (2.4)
Have students write their reflections (e.g., in their journals, on exit tickets) in class or for homework	42 (3.3)	44 (2.7)
Have students read from a textbook, module, or other material in class, either aloud or to themselves	40 (3.3)	37 (2.1)
Engage the class in project-based learning (PBL) activities*	24 (3.0)	32 (2.8)
Have students practice for standardized tests	18 (2.5)	17 (1.7)
Use flipped instruction (have students watch lectures/demonstrations outside of class to prepare for in-class activities)*	14 (2.6)	8 (1.1)
Middle		
Engage the whole class in discussions	91 (1.8)	89 (1.3)
Explain science ideas to the whole class	94 (1.6)	91 (1.2)
Have students work in small groups	84 (3.2)	89 (2.0)
Focus on literacy skills (e.g., informational reading or writing strategies)	50 (4.5)	43 (2.7)
Have students do hands-on/laboratory activities*	52 (4.5)	68 (2.4)
Have students write their reflections (e.g., in their journals, on exit tickets) in class or for homework	47 (4.4)	48 (2.2)
Have students read from a textbook, module, or other material in class, either aloud or to themselves	43 (3.9)	38 (3.3)
Engage the class in project-based learning (PBL) activities	29 (4.5)	32 (2.7)
Have students practice for standardized tests	20 (3.0)	18 (2.1)
Use flipped instruction (have students watch lectures/demonstrations outside of class to prepare for in-class activities)	9 (1.8)	10 (1.7)
High		
Engage the whole class in discussions	76 (2.8)	78 (1.6)
Explain science ideas to the whole class	92 (2.0)	92 (1.0)
Have students work in small groups	82 (3.0)	85 (1.7)
Focus on literacy skills (e.g., informational reading or writing strategies)	36 (3.0)	31 (1.9)
Have students do hands-on/laboratory activities*	57 (3.2)	71 (1.9)
Have students write their reflections (e.g., in their journals, on exit tickets) in class or for homework	30 (2.7)	27 (1.7)
Have students read from a textbook, module, or other material in class, either aloud or to themselves	30 (3.0)	24 (1.8)
Engage the class in project-based learning (PBL) activities	25 (3.3)	28 (1.8)
Have students practice for standardized tests	22 (2.7)	20 (1.8)
Use flipped instruction (have students watch lectures/demonstrations outside of class to prepare for in-class activities)	15 (2.4)	15 (1.4)

* There is a statistically significant difference between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p < 0.05$).

The survey also asked how often students in science classes were 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 54, 40 percent or fewer elementary classes engaged with any of the science practices on a weekly basis. Engagement with the practices, although still quite low, tended to increase at the secondary level (see Tables 55 and 56). For example, about half of middle classes included opportunities for students to generate scientific questions, make and support claims with evidence, and conduct scientific investigations as least once a week. At the high school level, roughly 50–60 percent of classes were likely to organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data on a weekly basis. However, across all grade bands, classes tended to not be engaged very often in aspects of science related to evaluating the strengths/limitations of evidence (e.g., evaluating the credibility of scientific information, identifying strengths and limitations of a scientific model) or the practice of argumentation (e.g., constructing a persuasive case, determining what details about an investigation might persuade a targeted audience about a scientific claim).

There were some differences in engagement with the science practices between classes taught by novices and those taught by veterans, particularly at the middle and high school levels. For example, middle school classes taught by novices were less likely than classes taught by veterans to organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data (35 vs. 55 percent) or consider how missing data or measurement error can affect the interpretation of data (15 vs. 24 percent) on a weekly basis. Similarly, high school classes taught by novices were less likely than classes taught by veterans to organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data (47 vs. 61 percent); conduct a scientific investigation (39 vs. 53 percent); analyze data using grade-appropriate methods in order to identify patterns, trends, or relationships (39 vs. 49 percent); and select and use grade-appropriate mathematical and/or statistical techniques to analyze data (24 vs. 32 percent). Conversely, high school classes taught by novices were more likely than classes taught by veterans to generate scientific questions (47 vs. 35 percent).

[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.

Table 54
Elementary Science Classes in Which Teachers Report Students Engaging in Various Aspects of Science Practices at Least Once a Week

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Generate scientific questions	40 (3.4)	37 (2.8)
Make and support claims with evidence	36 (3.7)	31 (2.5)
Conduct a scientific investigation	35 (3.6)	37 (2.8)
Organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data	35 (3.4)	34 (2.8)
Use multiple sources of evidence to develop an explanation	32 (3.5)	24 (2.5)
Determine what data would need to be collected in order to answer a scientific question	30 (3.5)	30 (2.6)
Analyze data using grade-appropriate methods in order to identify patterns, trends, or relationships	27 (3.4)	27 (2.6)
Develop procedures for a scientific investigation to answer a scientific question	26 (3.3)	31 (2.6)
Revise their explanations based on additional evidence	22 (3.3)	22 (2.4)
Develop scientific models—physical, graphical, or mathematical representations of real-world phenomena	22 (3.4)	18 (2.4)
Compare data from multiple trials or across student groups for consistency in order to identify potential sources of error or inconsistencies in the data	22 (3.7)	17 (2.9)
Use data and reasoning to defend, verbally or in writing, a claim or refute alternative scientific claims	22 (3.3)	16 (1.8)
Determine whether or not a question is scientific	21 (2.9)	19 (1.8)
Summarize patterns, similarities, and differences in scientific information obtained from multiple sources	20 (2.9)	18 (2.7)
Select and use grade-appropriate mathematical and/or statistical techniques to analyze data	17 (3.1)	14 (1.6)
Pose questions that elicit relevant details about the important aspects of a scientific argument	17 (2.9)	13 (1.5)
Determine what details about an investigation might persuade a targeted audience about a scientific claim*	16 (3.1)	9 (1.2)
Identify the strengths and limitations of a scientific model—in terms of accuracy, clarity, generalizability, accessibility to others, strength of evidence supporting it	14 (2.7)	12 (2.4)
Evaluate the strengths and weaknesses of competing scientific explanations	14 (2.7)	11 (1.4)
Use mathematical and/or computational models to generate data to support a scientific claim	14 (2.7)	11 (1.3)
Consider how missing data or measurement error can affect the interpretation of data	13 (2.8)	14 (1.9)
Construct a persuasive case, verbally or in writing, for the best scientific model or explanation for a real-world phenomenon	13 (2.5)	9 (1.2)
Evaluate the credibility of scientific information—e.g., its reliability, validity, consistency, logical coherence, lack of bias, or methodological strengths and weaknesses	9 (2.2)	8 (1.2)

* There is a statistically significant difference between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p < 0.05$).

Table 55
Middle School Science Classes in Which Teachers Report Students Engaging in Various Aspects of Science Practices at Least Once a Week

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Make and support claims with evidence	47 (4.6)	53 (2.3)
Conduct a scientific investigation	45 (4.3)	49 (2.7)
Generate scientific questions	45 (3.9)	43 (2.3)
Analyze data using grade-appropriate methods in order to identify patterns, trends, or relationships	39 (4.5)	45 (2.7)
Determine what data would need to be collected in order to answer a scientific question	38 (3.3)	39 (2.8)
Use multiple sources of evidence to develop an explanation	38 (3.7)	37 (2.6)
Organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data*	35 (3.7)	55 (2.7)
Develop procedures for a scientific investigation to answer a scientific question	32 (3.6)	36 (2.6)
Develop scientific models—physical, graphical, or mathematical representations of real-world phenomena	31 (4.0)	35 (2.9)
Use data and reasoning to defend, verbally or in writing, a claim or refute alternative scientific claims	30 (2.7)	27 (2.3)
Revise their explanations based on additional evidence	29 (3.4)	30 (2.8)
Pose questions that elicit relevant details about the important aspects of a scientific argument	28 (3.8)	23 (2.1)
Compare data from multiple trials or across student groups for consistency in order to identify potential sources of error or inconsistencies in the data	26 (4.0)	34 (2.8)
Determine whether or not a question is scientific	26 (3.1)	33 (2.4)
Select and use grade-appropriate mathematical and/or statistical techniques to analyze data	25 (3.8)	18 (1.8)
Summarize patterns, similarities, and differences in scientific information obtained from multiple sources	23 (2.3)	26 (2.6)
Evaluate the credibility of scientific information—e.g., its reliability, validity, consistency, logical coherence, lack of bias, or methodological strengths and weaknesses	22 (3.5)	17 (2.0)
Identify the strengths and limitations of a scientific model—in terms of accuracy, clarity, generalizability, accessibility to others, strength of evidence supporting it	20 (3.4)	22 (2.6)
Evaluate the strengths and weaknesses of competing scientific explanations	19 (3.1)	19 (2.3)
Construct a persuasive case, verbally or in writing, for the best scientific model or explanation for a real-world phenomenon	18 (3.1)	16 (1.9)
Use mathematical and/or computational models to generate data to support a scientific claim	17 (2.8)	19 (1.9)
Determine what details about an investigation might persuade a targeted audience about a scientific claim	17 (2.9)	14 (2.1)
Consider how missing data or measurement error can affect the interpretation of data*	15 (2.9)	24 (2.5)

* There is a statistically significant difference between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p < 0.05$).

Table 56
High School Science Classes in Which Teachers Report Students Engaging in Various Aspects of Science Practices at Least Once a Week

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Organize and/or represent data using tables, charts, or graphs in order to facilitate analysis of the data*	47 (3.7)	61 (1.8)
Make and support claims with evidence	47 (3.6)	51 (1.9)
Generate scientific questions*	47 (3.5)	35 (2.0)
Determine what data would need to be collected in order to answer a scientific question	41 (3.5)	39 (1.6)
Conduct a scientific investigation*	39 (3.4)	53 (1.8)
Analyze data using grade-appropriate methods in order to identify patterns, trends, or relationships*	39 (3.4)	49 (1.8)
Use multiple sources of evidence to develop an explanation	35 (3.3)	33 (2.0)
Compare data from multiple trials or across student groups for consistency in order to identify potential sources of error or inconsistencies in the data	33 (3.2)	37 (2.0)
Develop scientific models—physical, graphical, or mathematical representations of real-world phenomena	33 (3.2)	34 (1.7)
Develop procedures for a scientific investigation to answer a scientific question	33 (3.6)	32 (1.6)
Summarize patterns, similarities, and differences in scientific information obtained from multiple sources	32 (3.3)	27 (1.8)
Revise their explanations based on additional evidence	29 (3.0)	28 (1.6)
Determine whether or not a question is scientific	27 (3.3)	29 (1.8)
Consider how missing data or measurement error can affect the interpretation of data	27 (3.5)	28 (1.7)
Use data and reasoning to defend, verbally or in writing, a claim or refute alternative scientific claims	27 (3.1)	27 (2.0)
Select and use grade-appropriate mathematical and/or statistical techniques to analyze data*	24 (3.0)	32 (1.8)
Pose questions that elicit relevant details about the important aspects of a scientific argument	24 (3.1)	22 (1.7)
Identify the strengths and limitations of a scientific model—in terms of accuracy, clarity, generalizability, accessibility to others, strength of evidence supporting it	24 (2.8)	21 (1.2)
Evaluate the strengths and weaknesses of competing scientific explanations	24 (2.9)	19 (1.8)
Use mathematical and/or computational models to generate data to support a scientific claim	22 (2.9)	27 (1.6)
Evaluate the credibility of scientific information—e.g., its reliability, validity, consistency, logical coherence, lack of bias, or methodological strengths and weaknesses	22 (3.2)	24 (1.6)
Construct a persuasive case, verbally or in writing, for the best scientific model or explanation for a real-world phenomenon	18 (2.9)	15 (1.1)
Determine what details about an investigation might persuade a targeted audience about a scientific claim	13 (2.2)	17 (1.4)

* There is a statistically significant difference between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p < 0.05$).

These items were combined into a composite variable called Engaging Students in the Practices of Science (see Table 57). The mean scores indicate that students engage in this set of practices to a limited extent. Although there were some item level differences, the mean scores for novices and veterans are not significantly different at any of the grade bands.

Table 57
Class Mean Scores for Engaging
Students in the Practices of Science Composite†

	MEAN SCORE	
	NOVICE	VETERAN
Elementary	40 (1.6)	38 (1.1)
Middle	50 (1.2)	50 (1.0)
High	50 (1.3)	50 (0.7)

† There are no significant differences between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p \geq 0.05$).

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 58, a typical science class at each grade band experienced engineering only a few times per year (roughly 50 percent of classes in each grade band). In terms of coding, more than two-thirds of classes in each grade band never included coding as part of their science instruction (see Table 59). These patterns held true for classes taught by novices and those taught by veterans.

Table 58
Science Classes in Which Teachers Report
Incorporating Engineering Into Science Instruction†

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Elementary		
Never	15 (3.0)	15 (2.2)
Rarely (e.g., a few times per year)	52 (4.9)	47 (3.0)
Sometimes (e.g., once or twice a month)	25 (4.3)	27 (2.8)
Often (e.g., once or twice a week)	5 (1.9)	10 (3.9)
All or almost all Science lessons	2 (1.1)	1 (0.6)
Middle		
Never	7 (3.6)	12 (2.2)
Rarely (e.g., a few times per year)	53 (5.3)	51 (3.1)
Sometimes (e.g., once or twice a month)	34 (4.8)	31 (2.5)
Often (e.g., once or twice a week)	4 (1.2)	5 (1.4)
All or almost all Science lessons	2 (1.5)	1 (0.6)
High		
Never	21 (3.2)	19 (1.9)
Rarely (e.g., a few times per year)	53 (3.9)	49 (2.2)
Sometimes (e.g., once or twice a month)	19 (3.2)	25 (1.8)
Often (e.g., once or twice a week)	6 (1.6)	6 (1.3)
All or almost all Science lessons	1 (0.5)	0 (0.2)

† There is not a significant difference in the distribution of responses between classes taught by novice and veteran teachers (Chi-square test of independence, $p \geq 0.05$).

Table 59
Science Classes in Which Teachers Report
Incorporating Coding Into Science Instruction[†]

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Elementary		
Never	72 (4.4)	69 (4.1)
Rarely (e.g., a few times per year)	17 (3.4)	15 (2.4)
Sometimes (e.g., once or twice a month)	8 (3.2)	12 (4.0)
Often (e.g., once or twice a week)	2 (1.3)	3 (1.0)
All or almost all Science lessons	0 ---[a]	0 ---[a]
Middle		
Never	77 (3.8)	82 (2.3)
Rarely (e.g., a few times per year)	18 (3.3)	13 (2.1)
Sometimes (e.g., once or twice a month)	3 (1.7)	3 (0.9)
Often (e.g., once or twice a week)	0 (0.5)	2 (0.7)
All or almost all Science lessons	1 (0.8)	0 (0.1)
High		
Never	87 (2.9)	90 (1.2)
Rarely (e.g., a few times per year)	7 (1.8)	6 (1.0)
Sometimes (e.g., once or twice a month)	6 (2.0)	3 (0.9)
Often (e.g., once or twice a week)	0 (0.0)	0 (0.1)
All or almost all Science lessons	0 (0.3)	0 (0.1)

† There is not a significant difference in the distribution of responses between classes taught by novice and veteran teachers (Chi-square test of independence, $p \geq 0.05$).

a No elementary science teachers in the sample selected this response option. Thus, it is not possible to calculate the standard error of this estimate.

In addition to asking about class activities in the course as a whole, teachers were asked about activities that took place during their most recent science lesson in a randomly selected class. As can be seen in Table 60, small group work and the teacher explaining science ideas to the whole class were very common at all three grade bands. Whole class discussions were also quite common, particularly in elementary classes. There were few differences in activities between classes taught by novices and those taught by veterans. At the elementary level, where there tends to be a substantial focus on literacy, classes taught by novices were less likely than classes taught by veterans to write about science (36 vs. 48 percent). At the high school level, classes taught by novices were more likely to watch the teacher conduct a demonstration than classes taught by veterans (41 vs. 29 percent).

Table 60
Science Classes Participating in Various Activities in Most Recent Lesson

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Elementary		
Whole class discussion	86 (2.6)	86 (1.2)
Teacher explaining a science idea to the whole class	85 (3.1)	83 (1.7)
Students working in small groups	75 (3.0)	79 (2.1)
Students reading about science	45 (3.6)	45 (2.6)
Students doing hands-on/laboratory activities	44 (4.0)	49 (2.5)
Teacher conducting a demonstration while students watched	42 (3.4)	34 (2.4)
Students completing textbook/worksheet problems	38 (3.8)	34 (2.0)
Students writing about science (does not include students taking notes)*	36 (3.8)	48 (2.7)
Test or quiz	14 (2.5)	8 (1.3)
Practicing for standardized tests	3 (1.0)	2 (0.7)
Middle		
Whole class discussion	67 (4.2)	66 (2.6)
Teacher explaining a science idea to the whole class	76 (3.9)	72 (2.2)
Students working in small groups	85 (3.1)	85 (1.6)
Students reading about science	50 (5.1)	46 (2.6)
Students doing hands-on/laboratory activities	43 (3.8)	48 (2.5)
Teacher conducting a demonstration while students watched	34 (4.0)	28 (2.2)
Students completing textbook/worksheet problems	40 (4.7)	38 (2.4)
Students writing about science (does not include students taking notes)	50 (4.6)	45 (3.2)
Test or quiz	15 (2.6)	14 (1.7)
Practicing for standardized tests	7 (1.8)	8 (1.2)
High		
Whole class discussion	63 (3.3)	58 (1.8)
Teacher explaining a science idea to the whole class	84 (2.6)	80 (1.6)
Students working in small groups	80 (2.7)	81 (1.4)
Students reading about science	34 (3.1)	28 (2.1)
Students doing hands-on/laboratory activities	37 (2.9)	41 (2.0)
Teacher conducting a demonstration while students watched*	41 (3.5)	29 (1.9)
Students completing textbook/worksheet problems	46 (3.4)	43 (1.8)
Students writing about science (does not include students taking notes)	33 (3.4)	34 (2.2)
Test or quiz	19 (3.0)	15 (1.3)
Practicing for standardized tests	12 (2.6)	7 (1.1)

* There is a statistically significant difference between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p < 0.05$).

The survey also asked teachers to estimate the time spent on each of a number of types of activities in their most recent science lesson. As can be seen in Table 61, the majority of class time, across grade bands, was spent on whole class activities (roughly 30–40 percent) and small group work (roughly 30–35 percent). However, classes taught by novices at the elementary and high school levels were less likely to devote time to small group work than classes taught by veterans (30 vs. 35 percent and 29 vs. 36 percent, respectively).

Table 61
Average Percentage of Time Spent on
Different Activities in the Most Recent Science Lesson

	PERCENT OF CLASS TIME	
	NOVICE	VETERAN
Elementary		
Whole class activities (e.g., lectures, explanations, discussions)	41 (1.4)	41 (1.1)
Small group work*	30 (1.5)	35 (1.4)
Students working individually (e.g., reading textbooks, completing worksheets, taking a test or quiz)	19 (1.3)	17 (0.9)
Non-instructional activities (e.g., attendance taking, interruptions)*	10 (0.8)	7 (0.4)
Middle		
Whole class activities (e.g., lectures, explanations, discussions)	32 (1.9)	32 (0.9)
Small group work	35 (2.2)	35 (1.3)
Students working individually (e.g., reading textbooks, completing worksheets, taking a test or quiz)	21 (1.7)	22 (0.9)
Non-instructional activities (e.g., attendance taking, interruptions)	12 (0.6)	11 (0.4)
High		
Whole class activities (e.g., lectures, explanations, discussions)	40 (1.9)	37 (0.8)
Small group work*	29 (1.6)	36 (0.9)
Students working individually (e.g., reading textbooks, completing worksheets, taking a test or quiz)	20 (1.5)	18 (0.9)
Non-instructional activities (e.g., attendance taking, interruptions)*	11 (0.5)	9 (0.2)

* There is a statistically significant difference between classes taught by novice and veteran teachers (Chi-square test of independence, $p < 0.05$).

Homework Practices

Teachers were asked about the amount of homework assigned per week. At the elementary level, the vast majority of classes were assigned 30 minutes or less of homework per week, with over half of classes assigned no homework in a given week (see Table 62). At the middle and high school grade bands, most classes were assigned 60 minutes or less of homework per week. However, fewer than 10 percent of classes at the secondary level were assigned no homework. These patterns are similar for classes taught by novices and classes taught by veterans.

Table 62
Amount of Homework Assigned in Classes Per Week†

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Elementary		
None	55 (4.5)	57 (3.4)
1–15 minutes per week	22 (3.6)	21 (2.7)
16–30 minutes per week	17 (2.9)	11 (1.4)
31–60 minutes per week	4 (1.6)	9 (3.7)
61–90 minutes per week	1 (0.9)	3 (1.6)
91–120 minutes per week	1 (0.5)	0 ---[a]
More than 2 hours per week	0 ---[a]	0 ---[a]
Middle		
None	7 (2.1)	9 (2.3)
1–15 minutes per week	21 (5.1)	13 (1.6)
16–30 minutes per week	30 (3.8)	35 (3.7)
31–60 minutes per week	30 (5.2)	31 (3.1)
61–90 minutes per week	7 (3.0)	8 (1.6)
91–120 minutes per week	3 (2.1)	2 (1.1)
More than 2 hours per week	2 (1.2)	2 (1.6)
High		
None	3 (1.4)	2 (0.6)
1–15 minutes per week	14 (3.0)	8 (1.4)
16–30 minutes per week	24 (3.9)	18 (1.5)
31–60 minutes per week	29 (3.8)	34 (1.9)
61–90 minutes per week	18 (3.3)	23 (2.2)
91–120 minutes per week	4 (1.1)	8 (1.0)
More than 2 hours per week	7 (2.7)	7 (1.4)

† There is not a significant difference in the distribution of responses between classes taught by novice and veteran teachers (Chi-square test of independence, $p \geq 0.05$).

a No elementary science teachers in the sample selected this response option. Thus, it is not possible to calculate the standard error of this estimate.

Instructional Resources

The survey also collected data on teachers' use of various types of instructional resources. As can be seen in Table 63, teacher-created units or lessons were very likely to be used on a weekly basis in classes taught by novices and veterans, and their prominence increased with increasing grade band. However, at the elementary and high school levels, classes taught by novices were less likely than classes taught by veterans to use units or lessons created by the teacher (40 vs. 50 percent and 79 vs. 88 percent, respectively). Lessons or resources from websites that have a subscription fee or per lesson cost and commercially published textbooks were also quite common across grade bands. At the secondary level, units or lessons teachers collected from other sources (e.g., conferences, journals, colleagues, university or museum partners) were also likely to be used on a weekly basis.

Table 63
Science Classes Basing Instruction on Various Instructional Resources at Least Once a Week, by Grade Range

	PERCENT OF CLASSES[a]	
	NOVICE	VETERAN
Elementary		
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)	55 (3.8)	48 (2.6)
Units or lessons you created (either by yourself or with others)*	40 (4.3)	50 (2.6)
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	39 (3.8)	39 (2.4)
State, county, district, or diocese-developed units or lessons	29 (3.3)	32 (2.9)
Commercially published kits/modules (printed or electronic)	28 (3.8)	30 (2.5)
Units or lessons you collected from any other source (e.g., conferences, journals, colleagues, university or museum partners)	23 (3.4)	30 (2.4)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	22 (3.0)	24 (2.7)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)	9 (2.1)	7 (1.3)
Middle		
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)	37 (3.1)	33 (2.4)
Units or lessons you created (either by yourself or with others)	74 (4.3)	77 (2.2)
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	41 (4.1)	47 (2.8)
State, county, district, or diocese-developed units or lessons	20 (2.6)	21 (2.4)
Commercially published kits/modules (printed or electronic)	17 (3.5)	23 (2.8)
Units or lessons you collected from any other source (e.g., conferences, journals, colleagues, university or museum partners)	47 (4.6)	40 (2.8)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	31 (3.4)	32 (2.2)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)	10 (1.9)	8 (1.1)
High		
Lessons or resources from websites that have a subscription fee or per lesson cost (e.g., BrainPOP, Discovery Ed, Teachers Pay Teachers)*	22 (2.5)	14 (1.4)
Units or lessons you created (either by yourself or with others)*	79 (2.4)	88 (1.1)
Commercially published textbooks (printed or electronic), including the supplementary materials (e.g., worksheets, laboratory handouts) that accompany the textbooks	50 (3.5)	49 (1.9)
State, county, district, or diocese-developed units or lessons	18 (2.6)	13 (1.1)
Commercially published kits/modules (printed or electronic)	19 (2.8)	21 (1.9)
Units or lessons you collected from any other source (e.g., conferences, journals, colleagues, university or museum partners)*	44 (3.0)	51 (1.8)
Lessons or resources from websites that are free (e.g., Khan Academy, PhET)	31 (3.0)	31 (2.1)
Online units or courses that students work through at their own pace (e.g., i-Ready, Edgenuity)	10 (2.0)	8 (1.2)

* There is a statistically significant difference between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p < 0.05$).

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

Teachers were asked whether the instructional materials used in their most recent unit were based primarily on either a commercially published textbook or materials developed by the state or district. As can be seen in Table 64, more than 50 percent of classes across grade bands were based on such materials. Further, classes taught by novices and veterans were equally likely to use one of these types of materials in their most recent unit.

Table 64

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[b]	
	NOVICE	VETERAN
Elementary	64 (4.0)	65 (2.8)
Middle	54 (4.5)	54 (2.8)
High	62 (4.4)	53 (2.0)

† There are no significant differences between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p \geq 0.05$).

Teachers who reported that their most recent unit was based on one of these types of materials were then asked how they used the materials. As can be seen in Table 65, teachers in over 70 percent of these classes across grade bands used these materials to substantially guide the overall structure and content emphasis of the unit. However, teachers also substantially modified these materials by incorporating activities from other sources, modifying activities, and skipping portions of the materials. It is worth noting that novices at the middle and high school levels were less likely than veterans to pick what was important from the materials and skip the rest (43 vs. 58 percent and 41 vs. 57 percent, respectively). At the high school level, novices were also less likely than veterans to modify activities from these materials (60 vs. 75 percent) and more likely to use these materials to guide the structure and content emphasis of the unit (87 vs. 73 percent). Given that novices felt less well prepared than their veteran counterparts to teach science content and utilize a number of pedagogical strategies, it is perhaps not surprising that they relied heavily on these materials and used them as written.

Table 65
Ways Science Teachers Substantially[a] Used Their Materials in Most Recent Unit, by Grade Range

	PERCENT OF CLASSES[b]	
	NOVICE	VETERAN
Elementary		
I used these materials to guide the structure and content emphasis of the unit.	81 (3.4)	75 (4.4)
I incorporated activities (e.g., problems, investigations, readings) from other sources to supplement what these materials were lacking.	63 (4.8)	67 (3.7)
I modified activities from these materials.	62 (5.2)	58 (3.6)
I picked what is important from these materials and skipped the rest.	47 (5.5)	54 (3.8)
Middle		
I used these materials to guide the structure and content emphasis of the unit.	75 (4.5)	71 (3.1)
I incorporated activities (e.g., problems, investigations, readings) from other sources to supplement what these materials were lacking.	69 (6.5)	81 (2.9)
I modified activities from these materials.	62 (6.3)	71 (3.5)
I picked what is important from these materials and skipped the rest*	43 (5.7)	58 (4.4)
High		
I used these materials to guide the structure and content emphasis of the unit.*	87 (2.3)	73 (2.5)
I incorporated activities (e.g., problems, investigations, readings) from other sources to supplement what these materials were lacking.	73 (4.1)	80 (2.5)
I modified activities from these materials.*	60 (4.4)	75 (3.0)
I picked what is important from these materials and skipped the rest.*	41 (5.7)	57 (3.4)

* There is a statistically significant difference between classes taught by novice and veteran teachers (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.

When teachers reported that they modified these materials (which over half at each grade band did), they were asked about factors that may have contributed to their decision to do so. As can be seen in Table 66, in more than three-quarters of classes at each grade band, the teacher, regardless of experience level, indicated not having enough time to implement the activities as designed. In over half of classes at each grade range, teachers cited a lack of materials/supplies as a reason for modifying materials. Lack of materials was particularly problematic for classes taught by novices at the elementary level (75 vs. 54 percent).

Table 66

Reasons Why Parts of Science Materials Are Modified,[a] by Grade Range

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Elementary		
I did not have enough instructional time to implement the activities as designed.	75 (7.5)	68 (5.6)
I did not have the necessary materials/supplies for the original activities.*	75 (4.2)	54 (4.8)
The original activities were too difficult conceptually for my students.	53 (6.5)	43 (5.2)
The original activities were not structured enough for my students.	43 (6.9)	42 (5.9)
The original activities were too easy conceptually for my students.	38 (6.2)	34 (4.4)
The original activities were too structured for my students.	33 (5.6)	38 (5.6)
Middle		
I did not have enough instructional time to implement the activities as designed.	76 (5.5)	67 (4.5)
I did not have the necessary materials/supplies for the original activities.	53 (7.1)	66 (4.4)
The original activities were too difficult conceptually for my students.	53 (7.4)	54 (4.6)
The original activities were not structured enough for my students.	51 (7.3)	37 (5.2)
The original activities were too easy conceptually for my students.	53 (6.9)	43 (4.9)
The original activities were too structured for my students.	36 (7.6)	33 (5.2)
High		
I did not have enough instructional time to implement the activities as designed.	76 (5.0)	69 (3.5)
I did not have the necessary materials/supplies for the original activities.	62 (6.3)	50 (4.2)
The original activities were too difficult conceptually for my students.*	71 (5.9)	54 (4.1)
The original activities were not structured enough for my students.	51 (6.4)	38 (4.0)
The original activities were too easy conceptually for my students.	47 (6.5)	44 (3.9)
The original activities were too structured for my students.	36 (5.6)	38 (3.8)

* There is a statistically significant difference between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p < 0.05$).

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

When asked about the adequacy of resources for science instruction, teachers of secondary classes were generally more likely than those of elementary classes to rate the availability of resources as adequate (see Table 67). Comparing novices to veterans, teachers of classes at the elementary and middle grade bands rated the adequacy of resources similarly. In contrast, novice teachers of high school classes were less likely than their veteran counterparts to think their access to instructional technology (63 vs. 73 percent), facilities (62 vs. 76 percent), equipment (58 vs. 78 percent), and consumable supplies (54 vs. 71 percent) was adequate.

Table 67
Adequacy[a] of Resources for Science Instruction, by Grade Range

	PERCENT OF CLASSES	
	NOVICE	VETERAN
Elementary		
Instructional technology (e.g., calculators, computers, probes/sensors)	48 (4.8)	50 (3.2)
Facilities (e.g., lab tables, electric outlets, faucets and sinks)	38 (4.3)	39 (3.3)
Equipment (e.g., thermometers, magnifying glasses, microscopes, beakers, photogate timers, Bunsen burners)	35 (4.5)	41 (3.3)
Consumable supplies (e.g., chemicals, living organisms, batteries)	31 (4.6)	31 (3.7)
Middle		
Instructional technology (e.g., calculators, computers, probes/sensors)	57 (4.8)	58 (3.3)
Facilities (e.g., lab tables, electric outlets, faucets and sinks)	56 (4.7)	64 (3.3)
Equipment (e.g., thermometers, magnifying glasses, microscopes, beakers, photogate timers, Bunsen burners)	52 (5.0)	61 (3.4)
Consumable supplies (e.g., chemicals, living organisms, batteries)	40 (4.6)	47 (3.5)
High		
Instructional technology (e.g., calculators, computers, probes/sensors)*	63 (3.7)	73 (2.4)
Facilities (e.g., lab tables, electric outlets, faucets and sinks)*	62 (3.8)	76 (2.3)
Equipment (e.g., thermometers, magnifying glasses, microscopes, beakers, photogate timers, Bunsen burners)*	58 (3.5)	78 (2.2)
Consumable supplies (e.g., chemicals, living organisms, batteries)*	54 (3.7)	71 (2.5)

* There is a statistically significant difference between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p < 0.05$).

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

These items were combined into a composite variable called Adequacy of Resources for Instruction. As can be seen in Table 68, mean scores were similar for classes taught by novices and veterans in the elementary and middle school grade bands. However, novice teachers of high school classes were less likely to have positive views about the adequacy of resources than veterans (mean scores of 68 vs. 78).

Table 68
Class Mean Scores for the Adequacy of Resources for Science Instruction Composite, by Subject

	MEAN SCORE	
	NOVICE	VETERAN
Elementary	50 (2.4)	53 (2.3)
Middle	62 (2.4)	67 (1.8)
High*	68 (2.1)	78 (1.3)

* There is a statistically significant difference between classes taught by novice and veteran teachers (two-tailed independent samples t-test, $p < 0.05$).

Summary

Novice and veteran science teachers primarily worked in public school settings and were relatively evenly distributed among rural, suburban, and urban settings. However novices were more likely than veterans to teach in high-poverty schools and less likely to teach in affluent schools.

When considering school context, large percentages of novices and veterans tended to work in schools where state standards wield a great deal of influence over science instruction, particularly at the middle and high school levels. Other school-level factors (e.g., science professional development policies and practices, the importance that the school places on science) were viewed as only moderately supportive of science instruction. Further, teacher issues, lack of resources, and student issues were somewhat problematic in schools at all three grade bands, but particularly at the elementary level.

Looking at teacher characteristics, large percentages of novices and veterans were female (particularly at the elementary level) and white. In terms of teaching experience, most novices were new to the teaching profession in general, not just new to science teaching. Although most teachers across grade bands had earned a teaching credential, novices at the secondary level appeared to be less likely to have a credential than their veteran counterparts.

Very few elementary teachers had a degree in science/engineering or science education, and only about one-third had coursework in Earth, life and physical science. At the secondary level, most middle and high school teachers had substantial background in life science/biology. A substantial proportion of novices at the high school level also had considerable background in chemistry. However, at the middle and high school grade bands, novices were less likely than veterans to have a substantial background in Earth science. In addition, novices at the high school level were less likely than veterans to have a substantial background in life science/biology, chemistry, and physics.

Nearly 60 percent of novice and veteran elementary teachers had participated in science-focused professional development in the previous three years; this percentage increased to 69 percent at the middle school level and 84 percent at the high school level. However, at the middle school level, novices were less likely than veterans to have participated in science professional development in the preceding three years. Further, novices at the middle and high school grade bands were less likely than their veteran counterparts to have participated in sustained professional development (more than 35 hours) during this time frame. Across grade bands, professional development opportunities for novices and veterans were not well aligned with elements of effective professional development and only moderately supported student-centered instruction.

Novice and veteran science teachers at the elementary, middle, and high school grade bands held a number of reform-oriented beliefs that are aligned with current thinking about effective science instruction (e.g., the teacher should ask students to support their conclusions about a science concept with evidence, students learn best when instruction is connected to their everyday lives). However, novices across grade bands also were more likely to hold traditional beliefs than their veteran counterparts. At the elementary level, novices were more likely than veterans to agree that teachers should explain an idea to students before having them consider evidence that relates to the idea. Similarly, at the middle and high school levels, novices were more likely than veterans to agree that students should be provided with definitions for new scientific vocabulary at the beginning of instruction on a science idea and that hands/on laboratory activities should be used primarily to reinforce a science idea that students have already learned.

Few elementary science teachers felt very well prepared to teach life, Earth, or physical science. At the secondary level, modest percentages of middle school teachers indicated feeling well prepared to teach science concepts across content areas; feelings of preparedness increased among novices and veterans at the high school level. However, at the secondary level, novices were significantly less likely than veterans to consider themselves very well prepared to teach a number of science topics. Further, sizable proportions of novices and veterans, across grade bands, indicated that they were not adequately prepared to teach engineering concepts.

In terms of pedagogical preparedness, fewer than half of classes were taught by teachers considering themselves very well prepared to carry out a number of instructional tasks (e.g., use formative assessment to monitor student understanding, develop students' conceptual understanding, develop students' abilities to do science). However, these percentages tended to increase with increasing grade band. Although there are no differences at the elementary or middle grade bands, novices at the high school level were less likely to feel pedagogically prepared than veterans.

When asked specifically about their preparedness to teach the content of a specific unit, most teachers did not feel very well prepared to monitor student understanding during the unit or anticipate difficulties that students may have with particular science ideas and procedures. Further, novices as each grade band felt less prepared in many of these areas than veterans.

Both novices and veterans felt much more in control of pedagogical decisions, such as determining the amount of homework to be assigned, than curriculum decisions, such as determining course goals and objectives. Data on instructional objectives indicate that classes heavily emphasized understanding science concepts, particularly at the secondary level. However, across grade bands, classes were only somewhat likely to emphasize reform-oriented instructional objectives, such as learning how to do science or learning about real-life applications of science/engineering.

Science instruction in classes taught by novices and veterans relied heavily on whole group discussions and teacher explanation of ideas. Further, survey data indicate that engagement with the science practices was limited, although it tended to increase with increasing grade range. Across grade levels, the majority of classes rarely incorporated engineering and never incorporated coding into science instruction.

Many classes were taught by teachers who relied on teacher-created units or lessons on a weekly basis. Lessons or resources that have a subscription fee; commercially published textbooks; and materials developed by the state, county, or district were also frequently used. Teachers using commercially published textbooks or materials published by their state or district often deviated from these materials by supplementing, modifying, or skipping parts of activities. However, novices tended to deviate less often than their veteran counterparts, likely due to their perceived lack of preparedness to teach science concepts and use various pedagogical strategies. Common reasons for modifications included lack of instructional time and lack of materials/supplies.

When asked about the adequacy of resources for science instruction, teachers at the secondary level were generally more likely than those at the elementary level to rate the availability of resources as adequate. However, novice teachers of high school classes were less likely than their veteran counterparts to report adequate access to instructional technology, facilities, equipment, or consumable supplies.