The Status of Secondary Science Education in the United States:

Factors that Predict Practice

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INTRODUCTION

Changes are coming for K–12 science education in the United States. New education guidelines, in the form of the Next Generation Science Standards (NGSS), will present new challenges for teachers in the creation of ambitious, scientific practice-based learning opportunities for students (National Research Council, 2011). In order to support teachers in meeting the new challenges presented by the NGSS, it is imperative to understand the status of science instruction. In this paper, we present findings from a large nationally representative survey of science teachers that provide answers to the following research questions:

1. What are the characteristics of the secondary science teaching force in terms of demographics, preparation, and perceptions of preparedness?
2. What factors predict secondary teachers' classroom teaching practices in science?

Science education research has illuminated many of the factors that influence classroom science instruction. To facilitate analysis, we consider five broad categories: teacher attributes, teacher perceptions of preparedness, instructional resources, context-related factors, and professional development (PD) participation. Teacher attributes include various forms of teacher knowledge (e.g., subject matter knowledge), teaching experience, type of teacher preparation program completed, teacher grade level, and other individual teacher-level factors. Studies reveal correlations between teacher attributes and science teaching practice (e.g., Smith, Desimone, Zeidner, Dunn, Bhatt, & Rumyantseva, 2007). Additionally, science teacher subject matter knowledge has been found to predict teaching practice (reviewed in Abell, 2007).

Teachers' beliefs concerning science, how it can/should be taught, and their own abilities to achieve successful student science learning outcomes also influence science teaching practice (reviewed in Jones & Carter, 2007; see also Nespor, 1987; Pajares, 1992). Pedagogical approaches are shaped by beliefs about what constitutes effective science instruction, which is informed by beliefs about the nature of science and goals of science education. Similarly, science teaching reflects beliefs about learners in general and a group of students in particular. Beliefs about one's own ability to successfully teach science (self-efficacy) also influence science teaching practice.

Instructional resources available to teachers—including texts, material resources for conducting investigations, and technology—influence classroom science instruction. Science teaching may be determined in large part by curriculum materials, particularly when teachers enact lessons and units with high levels of fidelity (Weiss, Pasley, Smith, Banilower, & Heck, 2003). Availability of materials for "hands-on" science can create affordances and constraints for classroom pedagogy, and may be important determinants of what a science lesson entails (e.g., Johnson, 2006). Finally, access to technological resources, such as computers and laboratory equipment/supplies, can impact science pedagogy (e.g., Lawless & Pellegrino, 2007).

Science teaching is also situated within larger contexts whose features affect classroom teaching practice. For example, policy considerations at the school, district, state, and national levels have impacts on what is and is not done in the name of science teaching (e.g., Knapp & Plecki, 2001; Shaver, Cuevas, Lee, & Avalos, 2007). Time allotted for science instruction is often limited, which has consequences for science pedagogy (Johnson, 2006).

Finally, although science teaching is often an individual teacher's endeavor, it is informed by teacher professional development, mentoring or coaching, and other forms of in-service teacher support. Professional development, mentoring, and coaching for science teachers can impact how science is taught in classrooms (e.g., Supovitz & Turner, 2000; Desimone, Porter, Garet, Yoon, & Birman, 2002; Luft, 2009).

STUDY DESIGN

Survey Measure

The survey is based on a national probability sample of schools and teachers in grades K–12 in the 50 states and the District of Columbia. The sample was designed to allow national estimates of science education indicators, including teacher background and instructional practices. Sample design involved clustering and stratification by elementary or secondary level, then by subject taught. Target sample sizes were designed to allow sub-domain estimates, such as for particular regions or types of community.

The school sampling frame was constructed from the Common Core of Data (CCD) and Private School Universe Survey databases, maintained by the National Center for Education Statistics. The teacher sampling frame was constructed from lists of current teachers and their specific subjects taught. In-depth data about curriculum and instruction in a single, randomly selected class was obtained from each teacher. Most secondary teachers taught several classes; for each teacher, one class was randomly selected for the focus of the survey.

Surveys were administered on-line. The study targeted 2,000 schools and approximately 5,000 teachers of science. The final response rates for school program questionnaires and teacher questionnaires were 83 percent and 77 percent, respectively.[1]

The survey collected a wide range of data about science teachers, including teaching experience, degrees earned, college-level science courses taken, perceptions of pedagogical and content preparedness, professional development experiences, and adequacy of resources for instruction. In addition, the school-level survey gathered data such as per pupil science expenditures, demographics of the student body, and whether the school used block scheduling.

To facilitate the reporting of large amounts of survey data, and because individual questionnaire items are potentially unreliable, we used factor analysis to identify survey questions that could be combined into "composites." The composites were derived through a multi-stage process. As a first step, to test whether the items intended to target the same underlying construct indeed showed similar response patterns, an exploratory factor analysis was conducted on a subset of

[1] The Report of the 2012 National Survey of Science and Mathematics (Banilower, et al., 2013) provides additional information about the study design. http://www.horizon-research.com/2012nssme/research-products/reports/technical-report/

the data. Based on item fit and conceptual coherence, preliminary composite definitions were created. Next, the preliminary composite definitions were applied to a different subset of the data and a confirmatory factor analysis was performed using Mplus version 6. Only composites with acceptable fit indices[2] and high reliability (as measured by Cronbach's coefficient alpha) were retained. For ease of interpretation, all composite scores were standardized and placed on a 0-100 scale. Items underlying the composites are available in the technical report (Banilower, et al., 2013).

To minimize teacher burden, teachers were randomly selected to receive one of two different survey versions. The majority of the questions were asked on both versions of the survey and referred to as "core items." Other questions were version specific and classified as either Matrix A or Matrix B items. Because of the nature of the sampling procedure and the use of design weights in the analyses, all results are representative of the science teaching population in the nation.

Analysis

In this paper we provide nationally representative descriptive information on a variety of characteristics of teachers and schools. In addition, we describe how these characteristics relate to two teaching practice outcomes measured on the teacher questionnaire: emphasis on reform-oriented instructional objectives and frequency of use of reform-oriented teaching practices. Table 1 shows the items that comprised these two composite outcomes.

Table 1
Definitions of Outcome Composite Variables

Reform-Oriented Instructional Objectives†	Reform-Oriented Teaching Practices‡
1. Understanding science concepts 2. Learning science process skills (e.g., observing, measuring) 3. Learning about real-life applications of science 4. Increasing students' interest in science 5. Preparing for further study in science	1. Have students work in small groups 2. Do hands-on/laboratory activities 3. Engage the class in project-based learning (PBL) activities 4. Have students represent and/or analyze data using tables, charts, or graphs 5. Require students to supply evidence in support of their claims 6. Have students write their reflections (e.g., in their journals) in class or for homework

† The questionnaire item read: "Think about your plans for this class for the entire course. By the end of the course, how much emphasis will each of the following student objectives receive?" Respondents answered on a scale from 1 (None) to 5 (Heavy Emphasis).

‡ The questionnaire item read: "How often do you do each of the following in your science instruction in this class?" Respondents answered on a scale from 1 (Never) to 5 (All or almost all science lessons).

In order to estimate the relationship between a number of factors and each outcome of interest (reform-oriented instructional objectives, reform-oriented teaching practices) a series of regression analyses was conducted, separately for middle school and high school teachers. Each

[2] The psychometric literature provides multiple criteria for judging acceptable model fit using these indices, ranging from 0.05–0.10 for both the root mean square error of approximation (RMSEA) and standardized root mean square residual (SRMR). The obtained values from final models are presented in the technical report.

outcome composite was regressed on a set of independent variables concerning teacher attributes, teacher perceptions, instructional resources, context-related factors, and PD participation. Several variables were transformed to meet model assumptions for normality. Design weights were used in all descriptive and analytic statistics. These models were analyzed using Wesvar 5.1.

RESULTS

The results of this study are presented by grade level: middle and high school. For each, a description of the characteristics of the teaching force in terms of teacher demographics, preparation, and perceptions of preparedness is presented, followed by results of the regression analyses.

Middle Grades Science Teachers and Their Teaching

The vast majority of middle school science teachers are female. Teachers from race/ethnic groups historically underrepresented in science[3] are also underrepresented in the middle school science teaching force; at a time when only 62 percent of the K–12 student enrollment is White and non-Hispanic, roughly 90 percent of science teachers in middle schools characterize themselves that way. As can be seen in Table 2, the majority of the middles school science teaching force is older than 40, raising some concerns about having an adequate supply of science teachers in the future.

[3] Includes teachers identifying themselves as American Indian or Alaskan Native, Black, Hispanic or Latino, or Native Hawaiian or Other Pacific Islander.

Table 2
Characteristics of the Middle School Science Teaching Force

	Percent of Teachers	
Sex		
Male	30	(2.0)
Female	70	(2.0)
Race		
White	90	(1.4)
Black or African-American	6	(1.2)
Hispanic or Latino	5	(1.0)
Asian	2	(0.8)
American Indian/Alaskan Native	0	(0.2)
Native Hawaiian/Other Pacific Islander	0	(0.1)
Two or more races†	1	(0.3)
Age		
≤ 30	11	(1.0)
31–40	28	(2.2)
41–50	28	(2.1)
51–60	26	(2.5)
61+	7	(1.5)
Experience Teaching any Subject at the K–12 Level		
0–2 years	9	(1.5)
3–5 years	14	(1.6)
6–10 years	22	(2.6)
11–20 years	33	(2.8)
≥ 21 years	22	(2.6)
Experience Teaching Science at the K–12 Level		
0–2 years	14	(1.7)
3–5 years	19	(1.8)
6–10 years	26	(2.6)
11–20 years	26	(2.1)
≥ 21 years	16	(2.4)
Experience Teaching at this School, any Subject		
0–2 years	22	(2.1)
3–5 years	22	(2.2)
6–10 years	24	(2.5)
11–20 years	23	(2.8)
≥ 21 years	8	(1.9)

† "Hispanic or Latino" was not included in the computation of this category.

In order to help students learn science content, teachers must themselves have a firm grasp of the important ideas in the discipline. Because direct measures of teachers' content knowledge were not feasible in this study, the survey used a number of proxy measures, including teachers' major areas of study and courses completed. As can be seen in Table 3, almost half of teachers of science at the middle grades level have college or graduate degrees in science.

Table 3
Middle School Science Teacher Degrees

	Percent of Teachers	
Science/Engineering	26	(2.0)
Science Education	27	(1.9)
Science/Engineering or Science Education	41	(2.5)

Teachers were also asked about their path to certification. As can be seen in Table 4, almost half of middle school science teachers completed an undergraduate program leading to a bachelor's degree and a teaching credential. The remaining teachers are approximately split between completing a master's program that also awarded a teaching credential and completing a post-baccalaureate credentialing program that did not include a master's degree. Less than five percent of middle school science teachers have not had any formal teacher preparation.

Table 4
Middle School Science Teachers' Paths to Certification

	Percent of Teachers
An undergraduate program leading to a bachelor's degree and a teaching credential	47 (3.6)
A post-baccalaureate credentialing program (no master's degree awarded)	23 (2.5)
A master's program that also awarded a teaching credential	26 (3.1)
No formal teacher preparation	4 (1.5)

As noted earlier, the questionnaire included a number of items about a single, randomly selected class. Middle and high school science teachers were shown a list of topics based on the subject of that class and asked how well prepared they felt to teach each of those topics at the grade levels they teach. The composite score indicates that, on average, middle school science classes are taught by teachers who feel fairly well prepared to teach the content of addressed in the class (see Table 5).

The questionnaire also asked teachers about their preparedness for a number of tasks associated with instruction, including how well prepared they feel to address diverse learners in their science/mathematics instruction (e.g., encouraging participation of each of a number of underrepresented groups). They were also asked about how well prepared they feel to monitor and address student understanding, focusing on a specific unit in the randomly selected class, a proxy for pedagogical content knowledge. As can be seen in Table 5, middle school science classes tend to be taught by teachers who feel fairly well prepared to teach the content of their randomly selected class, and fairly well prepared for teaching the most recent unit.

Middle school science classes also tend to be taught by teachers who feel prepared to encourage student interest and participation in science and/or engineering. However, it is less likely that these classes are taught by teachers who feel well prepared to teach diverse learners, including classes with different levels of prior achievement, English-language learners, and students with learning or physical disabilities.

Table 5
Middle School Science Class Mean Scores for
Teacher Perceptions of Preparedness Composites

	Mean Score
Perceptions of Content Preparedness	72 (1.3)
Preparedness to Implement Instruction in Particular Unit	79 (0.8)
Preparedness to Encourage Students in Science/Engineering	75 (1.3)
Preparedness to Teach Diverse Learners	58 (1.3)

The survey also asked teachers about their perceptions of control over curricular and instructional decisions. These items were combined into two composites—Curriculum Control and Pedagogical Control. Curriculum Control comprises the following items:

- Determining course goals and objectives;
- Selecting content, topics, and skills to be taught; and
- Selecting textbooks/modules/programs.

For Pedagogical Control, the items are:

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

As can be seen in Table 6, teachers of middle school science classes perceive much more control over pedagogical decisions than their curriculum.

Table 6
Middle School Science Class Mean Scores for
Curriculum Control and Pedagogical Control Composites

	Mean Score
Curriculum	45 (2.2)
Pedagogical	88 (1.3)

To get a sense of the nature of instruction happening in science classrooms, two composites were created: Reform-oriented Instructional Objectives and Reform-oriented Teaching Practices. Defined earlier in Table 1, reform-oriented objectives include a focus on developing conceptual understanding, science process skills, and real-life applications of science. The reform-oriented practices composite encompasses activities such as hands-on/laboratory work; having students represent and/or analyze data using tables, charts, or graphs; and requiring students to supply evidence in support of their claims. Table 7 shows the class mean scores for both composites.

Table 7
Middle School Science Class
Mean Scores for Instruction Composites

	Mean Score
Reform-oriented Instructional Objectives	83 (0.6)
Reform-oriented Teaching Practices	63 (0.6)

Regression Model Results

Table 8 shows the regression results for the Reform-oriented Instructional Objectives composite. The regression models explain approximately one-third of the variance in the degree of emphasis on reform-oriented instructional objectives in middle school science classes. (Descriptive statistics on the analytic sample are available in the Appendix.)

Several teacher-level variables are significantly related to emphasis on these objectives in middle school classes. Teachers' perceptions of their preparedness to encourage student participation in science/engineering and their perceptions of pedagogical content knowledge (as measured by the Preparedness to Implement Instruction in a Particular Unit composite) were significant, positive predictors of the emphasis on reform-oriented instructional objectives. Teachers' perceptions of content preparedness were also related to an emphasis on reform-oriented objectives; classes taught by teachers who indicated that they felt better prepared to teach the course content were more likely to have reform-oriented instructional objectives. Interestingly, classes taught by teachers with a degree in the natural sciences or engineering were less likely to have an emphasis on reform objectives.

The only significant class-level predictor was prior achievement level. Classes consisting of mostly high achievers were less likely to have an emphasis on reform-oriented objectives than classes of mostly average achievers. Classes in schools that spent more money per pupil for science instruction also tended to have a greater emphasis on reform-oriented objectives.

Table 8
Predictors of Emphasis on Reform-Oriented Objectives: Middle School Results

	Model					
	Core		Matrix A		Matrix B	
Predictors	Coeff.	SE	Coeff.	SE	Coeff.	SE
Intercept	36.81	24.46				
Teacher-Level Predictors						
Years of K–12 Teaching Experience†	-0.32	0.76				
Degree in Education, including Science Education	2.66	2.95				
Degree in Natural Science and/or Engineering	-7.37*	2.64				
Degree in Other Field	-2.29	2.27				
3+ Advanced Courses in Subject Taught	3.65	2.14				
Perceptions of Content Preparedness†	0.20*	0.05				
Preparedness to Implement Instruction in Particular Unit†	0.18*	0.04				
Amount of Science PD in past 3 Years (vs. None)						
Less than 6 Hours	6.40	5.15				
6–15 Hours	3.26	4.91				
16–35 Hours	3.84	5.76				
35 or more Hours	2.15	5.67				
Participated in a PLC in the past 3 Years	-4.07	2.45				
Preparedness to Teach Diverse Learners			0.18	0.09		
Preparedness to Encourage Students in Science/Engineering†			0.14*	0.06		
Teacher Certification Program (vs. Undergraduate Program)						
Master's Program that awarded a credential			-3.10	3.52		
Post-Baccalaureate credentialing Program			-1.96	3.81		
Class-Level Predictors						
Subject Matter of Class (vs. General/Integrated Science)						
Life Science Class	-0.71	2.85				
Earth Science Class	2.93	3.29				
Physical Science Class	3.74	3.06				
Prior Achievement Level (vs. Mostly Average/Mix of Levels)						
Mostly Low Achievers	3.48	3.48				
Mostly High Achievers	-7.14*	2.87				
Class size	-0.06	0.21				
Percent Non-Asian Minority Students†	-0.61	0.46				
Instructional Materials (vs. Non-commercially Published)						
Textbook	1.44	3.11				
Module	4.61	3.41				
A Mix of Textbooks and Modules	0.32	3.27				
Adequacy of Resources for Science Instruction†	0.00	0.05				
Extent Quality of IT is Problematic†			-0.07	0.06		
Curriculum Control†					0.04	0.27
Pedagogical Control†					0.03	0.04
Extent Policy Environment Promotes Effective Instruction					0.12	0.11
Extent Stakeholders Promote Effective Instruction					-0.09	0.08
Extent School Support Promotes Effective Instruction†					-0.01	0.06
School Context Predictors						
School Location (vs. Urban Area)						
Rural Area	6.27	3.86				
Suburban Area	2.76	3.02				
Percent of Students eligible for FRL	0.01	0.05				
Money Spent per Pupil for Science Instruction†	16.57*	8.00				
Supportive Context for Science Instruction†	-0.04	0.06				
Extent Lack of Materials/Supplies is Problematic†	0.28	0.19				
Extent Student Issues Are Problematic†	-0.37	0.47				
Extent Teacher Issues Are Problematic (vs. Score < 25)						
Composite Score between 25–49	1.79	2.71				
Composite Score 50 or above	-1.77	4.50				
Extent Lack of Time for Science is Problematic†	0.02	0.21				

† Indicates a variable that was transformed to address normality issues.

* $p < 0.05$

Notes: R^2 = 0.22 for Core Model; R^2 = 0.39 for Matrix A Model; R^2 = 0.32 for Matrix B Model

Table 9 shows the regression results for the use of reform-oriented teaching practices outcome. The statistical models explained slightly over one-third of the variance in the use of reform-oriented teaching practices in middle school science classes.

In terms of teacher-level predictors, classes taught by teachers with stronger perceptions of PCK were more likely to experience reform-oriented teaching practices. These practices were also significantly and positively related to teachers' perceptions of preparedness to teach diverse learners. At the class level, reform-oriented teaching practices were associated with greater emphasis on reform-oriented instructional objectives and higher ratings of the adequacy of resources for science instruction. At the school level, classes in rural schools tend to experience reform-oriented instruction more frequently than classes in urban schools.

Table 9
Predictors of Reform-Oriented Teaching Practices: Middle School Results

	Model					
	Core		**Matrix A**		**Matrix B**	
Predictors	**Coeff.**	**SE**	**Coeff.**	**SE**	**Coeff.**	**SE**
Intercept	52.93	13.37				
Teacher-Level Predictors						
Years of K–12 Teaching Experience†	-0.04	0.41				
Degree in Education, including Science Education	-0.86	1.61				
Degree in Natural Science and/or Engineering	-1.20	1.50				
Degree in Other Field	-2.83	1.63				
3+ Advanced Courses in Subject Taught	-1.14	1.39				
Perceptions of Content Preparedness†	-0.02	0.02				
Preparedness to Implement Instruction in Particular Unit†	0.06*	0.02				
Amount of Science PD in past 3 Years (vs. None)						
Less than 6 Hours	-4.16	3.24				
6–15 Hours	-3.51	2.78				
16–35 Hours	-4.63	2.78				
35 or more Hours	-5.59	2.93				
Participated in a PLC in the past 3 Years	-2.08	1.97				
Preparedness to Teach Diverse Learners			0.16*	0.05		
Preparedness to Encourage Students in Science/Engineering†			-0.05	0.03		
Teacher Certification Program (vs. Undergraduate Program)						
Master's Program that awarded a credential			0.64	2.23		
Post-Baccalaureate credentialing Program			-3.82	2.19		
Class-Level Predictors						
Subject Matter of Class (vs. General/Integrated Science)						
Life Science Class	0.14	1.72				
Earth Science Class	-0.84	1.66				
Physical Science Class	-2.08	2.03				
Prior Achievement Level (vs. Mostly Average/Mix of Levels)						
Mostly Low Achievers	2.29	1.43				
Mostly High Achievers	0.50	1.59				
Class size	-0.03	0.12				
Percent Non-Asian Minority Students†	-0.16	0.29				
Instructional Materials (vs. Non-commercially Published)						
Textbook	2.45	1.61				
Module	2.90	2.03				
A Mix of Textbooks and Modules	-1.38	2.01				
Use of Reform-Oriented Instructional Objectives†	0.18*	0.03				
Adequacy of Resources for Science Instruction†	0.09*	0.03				
Extent Quality of IT is Problematic†			0.03	0.03		
Curriculum Control†					-0.10	0.22
Pedagogical Control†					0.05	0.02
Extent Policy Environment Promotes Effective Instruction					0.06	0.07
Extent Stakeholders Support Promotes Effective Instruction					0.10	0.05
Extent School Support Promotes Effective Instruction†					-0.09	0.04
School Context Predictors						
School Location (vs. Urban Area)						
Rural Area	5.01*	1.94				
Suburban Area	2.71	1.48				
Percent of Students eligible for FRL	0.03	0.04				
Money Spent per Pupil for Science Instruction†	2.04	4.05				
Supportive Context for Science Instruction†	-0.03	0.04				
Extent Lack of Materials/Supplies is Problematic†	0.08	0.14				
Extent Student Issues Are Problematic†	-0.32	0.34				
Extent Teacher Issues Are Problematic (vs. Score < 25)						
Composite Score Between 25–49	4.13*	1.87				
Composite Score 50 or above	0.47	2.24				
Extent Lack of Time for Science is Problematic†	-0.01	0.13				

† Indicates a variable that was transformed to address normality issues.

* $p < 0.05$

Notes: R^2 = 0.28 for Core Model; R^2 = 0.38 for Matrix A Model; R^2 = 0.44 for Matrix B Model

High School Science Teachers and Their Teaching

In contrast to middle school science teachers, roughly half of the high school science teaching force is male. The vast majority of science teachers at the high school level are White. Similar to the middle school teaching force, the majority of high school science teachers are older than 40 and have more than five years of science teaching experience.

Table 10
Characteristics of the High School Science Teaching Force

	Percent of Teachers	
Sex		
Male	46	(1.4)
Female	54	(1.4)
Race		
White	92	(0.8)
Black or African-American	3	(0.5)
Hispanic or Latino	4	(0.6)
Asian	2	(0.5)
American Indian/Alaskan Native	0	(0.2)
Native Hawaiian/Other Pacific Islander	0	(0.2)
Two or more races†	2	(0.4)
Age		
≤ 30	16	(1.4)
31–40	30	(1.3)
41–50	24	(1.3)
51–60	22	(1.3)
61+	7	(1.0)
Experience Teaching any Subject at the K–12 Level		
0–2 years	14	(1.3)
3–5 years	13	(0.9)
6–10 years	23	(1.4)
11–20 years	30	(1.6)
≥ 21 years	19	(1.3)
Experience Teaching Science at the K–12 Level		
0–2 years	13	(1.1)
3–5 years	15	(1.2)
6–10 years	23	(1.5)
11–20 years	31	(1.4)
≥ 21 years	18	(1.1)
Experience Teaching at this School, any Subject		
0–2 years	23	(1.3)
3–5 years	21	(1.2)
6–10 years	23	(1.4)
11–20 years	24	(1.3)
≥ 21 years	9	(1.0)

† "Hispanic or Latino" was not included in the computation of this category.

As can be seen in Table 11, over 60 percent of teachers of science at the high school level have college or graduate degrees in science. Nearly half have a degree in science education. These figures are in sharp contrast to those of middle school teachers, who are far less likely to have earned a degree in science or science education.

Table 11
High School Science Teacher Degrees

	Percent of Teachers
Science/Engineering	61 (1.6)
Science Education	48 (1.4)
Science/Engineering or Science Education	82 (1.3)

High school teachers with a teaching certificate are almost evenly split among the three pathways to certification (see Table 12). Less than 10 percent of high school science teachers have not had any formal teacher preparation.

Table 12
High School Science Teachers' Paths to Certification, by Grade Range

	Percent of Teachers
An undergraduate program leading to a bachelor's degree and a teaching credential	34 (2.0)
A post-baccalaureate credentialing program (no master's degree awarded)	30 (1.9)
A master's program that also awarded a teaching credential	28 (1.8)
No formal teacher preparation	8 (1.3)

Teachers of high school science classes report feeling well prepared in their respective content topic areas (see Table 13). On average, high school science classes are more likely than middle school science classes to be taught by teachers with higher perceptions of content preparedness. High school classes also tend to be taught by teachers who feel well prepared to implement instruction in a particular unit and encourage student interest in science and engineering. Similar to middle school science classes, high school science classes tend to be taught by teachers who feel less well prepared to teach diverse learners.

Table 13
High School Science Class Mean Scores for Teacher Perceptions of Preparedness Composites

	Mean Score
Perceptions of Content Preparedness	86 (0.7)
Preparedness to Implement Instruction in Particular Unit	82 (0.6)
Preparedness to Encourage Students in Science/Engineering	78 (1.1)
Preparedness to Teach Diverse Learners	59 (1.1)

Table 14 displays the composite scores for Curriculum Control and Pedagogical Control for teachers of high school science classes. Similar to the middle school results, teachers of high school science classes perceive much more control over decisions related to pedagogy than curriculum.

Table 14
High School Science Class Mean Scores for
Curriculum Control and Pedagogical Control Composites

	Mean Score
Curriculum	59 (1.6)
Pedagogical	89 (0.7)

Instruction, as measured by the reform-oriented objectives and teaching practices composites, in high school science classes is similar to that in middle school science classes (see Table 15). Although high school classes are likely to emphasize reform-oriented instructional objectives, they are less likely to experience reform-oriented instructional practices.

Table 15
High School Science Class
Mean Scores for Instruction Composites

	Mean Score
Reform-oriented Instructional Objectives	82 (0.4)
Reform-oriented Teaching Practices	59 (0.5)

Regression Model Results

Table 16 shows the regression results for the Reform-oriented Instructional Objectives composite. The regression models explain approximately one-third of the variance in the degree of emphasis on reform-oriented instructional objectives in high school science classes. (Descriptive information on the analytic sample is available in the Appendix.)

Emphasis on reform-oriented objectives in high school science classes was significantly related to several teacher factors. Teachers who reported feeling more control over their pedagogical approach, who felt prepared to teach diverse learners, and who had higher perceptions of PCK were all more likely to emphasize these objectives in their classes. Participation in a professional learning community or lesson study was related to less emphasis on reform-oriented objectives.

At the class level, classes classified as consisting of mostly low achievers relative to the rest of the school were more likely to have an emphasis on reform-oriented objectives. Classes taught by teachers who have greater perceptions of pedagogical control also had more of a focus on these objectives. In addition, greater support from stakeholders predicted greater emphasis on reform-oriented objectives.

Table 16
Predictors of Emphasis on Reform-Oriented Objectives: High School Results

	Model					
	Core		Matrix A		Matrix B	
Predictors	Coeff.	SE	Coeff.	SE	Coeff.	SE
Intercept	39.00	14.53				
Teacher-Level Predictors						
Years of K–12 Teaching Experience†	-0.49	0.52				
Degree in Education, including Science Education	-2.79	1.93				
Degree in Natural Science and/or Engineering	1.98	2.00				
Degree in Other Field	4.10	2.46				
3+ Advanced Courses in Subject Taught	-2.58	2.55				
Perceptions of Content Preparedness†	0.04	0.02				
Preparedness to Implement Instruction in Particular Unit†	0.27*	0.04				
Science PD in past 3 Years (vs. None)						
Less than 6 Hours	-3.47	4.41				
6–15 Hours	-4.16	2.62				
16–35 Hours	-2.66	2.64				
35 or more Hours	-3.95	2.83				
Participated in a PLC in the past 3 Years	-4.58*	1.59				
Preparedness to Teach Diverse Learners			0.16*	0.07		
Preparedness to Encourage Students in Science/Engineering†			0.11	0.05		
Teacher Certification Program (vs. Undergraduate Program)						
Master's Program that awarded a credential			2.41	2.79		
Post-Baccalaureate credentialing Program			3.71	3.45		
Class-Level Predictors						
Subject Matter of Class (vs. General/Integrated/Physical Sci.)						
Life Science/Biology Class	5.35	3.27				
Earth Science/Space Science Class	4.12	4.07				
Chemistry Class	7.86*	3.43				
Physics Class	4.11	3.45				
Level of Course (vs. First Year College Prep, including Honors)						
Non-college Preparatory	0.78	2.46				
Second Year Advanced	-3.22	2.86				
Prior Achievement Level (vs. Mostly Average/Mix of Levels)						
Mostly Low Achievers	7.38*	2.67				
Mostly High Achievers	0.27	2.04				
Class size	0.00	0.13				
Percent Non-Asian Minority Students†	-0.42	0.31				
Instructional Materials Used (vs. Non-commercially Published)						
Textbook	-1.55	1.74				
Module	-2.37	4.59				
A Mix of Textbooks and Modules	-5.11	2.66				
Adequacy of Resources for Science Instruction†	-0.05	0.03				
Extent to Which the Quality of IT is Problematic†			0.04	0.05		
Curriculum Control					0.00	0.05
Pedagogical Control†					0.13*	0.04
Extent Policy Environment Promotes Effective Instruction					0.04	0.06
Extent Stakeholder Support Promotes Effective Instruction					0.17*	0.06
Extent School Support Promotes Effective Instruction†					-0.05	0.04
School Context Predictors						
School Location (vs. Urban Area)						
Rural Area	-0.55	2.57				
Suburban Area	-1.45	2.36				
Percent of Students eligible for FRL†	0.07	0.21				
Money Spent per Pupil for Science Instruction†	2.26	2.45				
Block Scheduling	0.20	1.59				
Supportive Context for Science Instruction†	0.01	0.04				
Extent Lack of Materials/Supplies is Problematic†	0.10	0.15				
Extent Student Issues Are Problematic	0.03	0.04				
Extent Teacher Issues Are Problematic (vs. Score < 25)						
Composite Score Between 25–49	3.64	2.02				
Composite Score 50 or above	1.30	3.63				
Extent Lack of Time for Science is Problematic†	0.12	0.17				

† Indicates a variable that was transformed to address normality issues.

* $p < 0.05$

Notes: R^2 = 0.20 for Core Model; R^2 = 0.36 for Matrix A Model; R^2 = 0.33 for Matrix B Model

Table 17 shows the regression results for the use of reform-oriented teaching practices outcome. Similar to the other models, these models explained slightly over one-third of the variance in the use of reform-oriented teaching practices in high school science classes.

Classes taught by teachers who had higher perceptions of PCK for their most recent unit were more likely to experience reform-oriented teaching practices, as were classes taught by teachers who feel better prepared to teach diverse learners. Years of teaching experience was negatively correlated with these practices. In other words, classes taught by more experienced teachers were less likely to experience reform-oriented teaching practices.

Not surprisingly, classes with a greater emphasis on reform-oriented instructional objectives were more likely to experience reform-oriented instruction. Stakeholder support for science instruction was also positively correlated with reform-oriented teaching practices. Although there were a few other significant coefficients, they do not follow a discernible pattern; for example, extent of teacher participation in professional development is negatively associated with reform-oriented teaching practices.

Table 17
Predictors of Reform-Oriented Teaching Practices: High School Results

Predictors	Core Coeff.	Core SE	Matrix A Coeff.	Matrix A SE	Matrix B Coeff.	Matrix B SE
Intercept	47.12	8.35				
Teacher-Level Predictors						
Years of K–12 Teaching Experience†	-1.38*	0.32				
Degree in Education, including Science Education	0.86	0.93				
Degree in Natural Science and/or Engineering	-0.92	1.02				
Degree in Other Field	2.35*	1.03				
3+ Advanced Courses in Subject Taught	-0.57	1.22				
Perceptions of Content Preparedness†	0.01	0.02				
Preparedness to Implement Instruction in Particular Unit†	0.06*	0.02				
Science PD in past 3 Years (vs. None)						
Less than 6 Hours	3.43	2.19				
6–15 Hours	-0.73	1.88				
16–35 Hours	-2.83	2.10				
35 or more Hours	-3.79*	1.80				
Participated in a PLC in the past 3 Years	-1.85	1.25				
Preparedness to Teach Diverse Learners			0.13*	0.04		
Preparedness to Encourage Students in Science/Engineering†			0.00	0.02		
Teacher Certification Program (vs. Undergraduate Program)						
Master's Program that awarded a credential			-0.48	1.52		
Post-Baccalaureate credentialing Program			-1.23	1.36		
Class-Level Predictors						
Subject Matter of Class (vs. General/Integrated/Physical Sci.)						
Life Science/Biology	2.97	1.62				
Earth Science/Space Science	2.44	2.00				
Chemistry	3.64*	1.71				
Physics	0.00	1.67				
Level of Course (vs. First Year College Prep, including Honors)						
Non-college Preparatory	-2.16	1.25				
Second Year Advanced	0.56	1.60				
Prior Achievement Level (vs. Mostly Average/Mix of Levels)						
Mostly Low Achievers	-1.71	1.26				
Mostly High Achievers	0.91	1.10				
Class size	0.00	0.07				
Percent Non-Asian Minority Students†	-0.23	0.17				
Instructional Materials Used (vs. Non-commercially Published)						
Textbook	1.69	1.02				
Module	-3.50	1.81				
A Mix of Textbooks and Modules	-1.06	1.23				
Use of Reform-Oriented Instructional Objectives†	0.19*	0.02				
Adequacy of Resources for Science Instruction†	-0.01	0.02				
Extent to Which the Quality of IT is Problematic†			0.02	0.02		
Curriculum Control					-0.01	0.03
Pedagogical Control†					-0.01	0.02
Extent Policy Environment Promotes Effective Instruction					-0.04	0.04
Extent Stakeholder Support Promotes Effective Instruction					0.12*	0.03
Extent School Support Promotes Effective Instruction†					-0.01	0.03
School Context Predictors						
School Location (vs. Urban Area)						
Rural Area	-0.14	0.92				
Suburban Area	0.17	1.02				
Percent of Students eligible for FRL†	-0.04	0.13				
Money Spent per Pupil for Science Instruction†	0.69	1.38				
Block Scheduling	-1.24	0.93				
Supportive Context for Science Instruction†	0.00	0.02				
Extent Lack of Materials/Supplies is Problematic†	0.01	0.09				
Extent Student Issues Are Problematic	0.04	0.03				
Extent Teacher Issues Are Problematic (vs. Score < 25)						
Composite Score Between 25–49	0.09	1.24				
Composite Score 50 or above	0.01	2.51				
Extent Lack of Time for Science is Problematic†	0.02	0.08				

† Indicates a variable that was transformed to address normality issues.

* $p < 0.05$

Notes: R^2 = 0.29 for Core Model; R^2 = 0.44 for Matrix A Model; R^2 = 0.36 for Matrix B Model

DISCUSSION

This paper provides data about the current status of secondary science teaching in the United States, shedding light on the preparation and practices of secondary science teachers. It also examines how teacher, classroom, and school factors relate to instructional practices. Five broad categories of predictive factors were explored: teacher attributes, teacher perceptions of preparedness, instructional resources, context-related factors, and PD participation.

Across the categories, factors in the category of teacher perceptions were most often related to the extent of emphasis on reform-oriented objectives and use of reform-oriented teaching practices in classrooms. Of these, perceptions of preparedness to implement a unit, a proxy for PCK, was a positive and significant predictor of reform-oriented objectives and reform-oriented practices at both the middle and high school levels. Similarly, perceptions of preparedness to encourage student interest in science and engineering and preparedness to teach diverse learners were positive predictors of reform-oriented objectives and practices.

Content preparedness was predictive for middle grades classes but not high school classes. This finding may be due to a lack of variation in content preparation at the high school level. High school classes were far more likely to be taught by teachers with a degree in a science field or science education and who report feeling well prepared to teach the science content. At the middle school level, there was more variation as fewer classes were taught by teachers with science/science education degrees, and middle school teachers reported lower feelings of preparedness than high school teachers.

Per pupil expenditures and adequacy of resources both related to a reform-oriented approach at the middle school level. Middle school classes with adequate resources to support science instruction were more likely to experience reform-oriented instruction. Prior achievement level of students and emphasis on reform-oriented objectives were also related in both middle and high school classes. At the middle school level, lower-achieving classes were more likely to have an emphasis on reform-oriented objectives compared to classes of average/mixed achievers; at the high school level, higher-achieving classes were less likely to have an emphasis on these objectives than classes of average/mixed achievers, perhaps due to the perception among teachers that they need to prepare students for college instruction.

Fewer patterns emerged in terms of teacher attributes, PD participation, and contextual factors. There was some indication that more experienced teachers are less likely to embrace reform-oriented practices. There is also some evidence that stakeholder support and pedagogical control are positive influences on reform-oriented teaching. However, these results were inconsistent across all models and should be interpreted with caution.

The variables included in the models explained between 20 and 44 percent of the total variation in the dependent variables. Although the explanatory power of these variables is substantial, there is still much variation left to be explained. The results may help to identify areas where additional research on teacher decision making is needed. In addition, the analyses presented here indicate that the relationships among teacher attributes and classroom practices are complex. It may be that relationships among the independent variables are masking relationships between them and the dependent variables. For example, if teacher credentials are related to teacher perceptions of preparedness, the relationships between each of these factors and the outcome variables may appear to be weaker than they truly are. Future analyses that examine mediating and moderating effects may help untangle these interrelationships.

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APPENDIX

Table A-1
Descriptive Information for Middle and High School Models: Categorical Variables

	Percent of Classes	
	Middle School (Unweighted N = 465)	**High School (Unweighted N = 903)**
Teacher-Level Variables		
Degree in Education, including Science Education	75	68
Degree in Natural Science and/or Engineering	31	62
Degree in Other Field	43	29
3+ Advanced Courses in Subject Taught	54	78
Amount of Science PD in past 3 Years		
None	12	12
Less than 6 Hours	11	6
6–15 Hours	21	21
16–35 Hours	20	21
35 or more Hours	36	41
Participated in a PLC in the past 3 years	68	68
Teacher Certification Program [Matrix A]		
Undergraduate Program	48	36
Master's Program that awarded a credential	31	31
Post-Baccalaureate Credentialing Program	31	33
Class-Level Variables		
Subject Matter of Class		
General/Integrated Science (Gr.6–8)	46	
Life Science Class (Gr.6–8)	20	
Earth Science Class (Gr.6–8)	16	
Physical Science Class (Gr.6–8)	17	
General/Integrated/Physical Sci. (Gr.9–12)		14
Life Science/Biology (Gr.9–12)		39
Earth Science/Space Science (Gr.9–12)		9
Chemistry (Gr.9–12)		23
Physics (Gr.9–12)		15
Level of Class		
First Year College Prep, including Honors		61
Non-college Preparatory		26
Second Year Advanced		14
Prior Achievement Level		
Mostly Average or Mix of Levels	70	57
Mostly Low Achievers	15	14
Mostly High Achievers	15	29
Instructional Materials Used		
Non-commercially Published	24	25
Textbook	42	59
Module	16	3
A Mix of Textbooks and Modules	19	13
School Context Variables		
School Location		
Urban Area	24	25
Rural Area	24	30
Suburban Area	52	45
Block Scheduling		
Extent Teacher Issues Are Problematic		35
Composite Score < 25	69	76
Composite Score Between 25–49	19	17
Composite Score 50 or above	12	6

Table A-2
Descriptive Information for Middle and High School Models: Continuous Variables

	Middle School Classes (Unweighted N = 465)		High School Classes (Unweighted N = 903)	
	Mean	**SD**	**Mean**	**SD**
Teacher-Level Variables				
Years of K-12 Teaching Experience	12.00	8.52	12.23	9.24
Perceptions of Content Preparedness	77.63	21.11	86.42	16.59
Preparedness to Implement Instruction in Particular Unit	79.66	17.88	81.60	17.23
Preparedness to Teach Diverse Learners [Matrix A]	59.15	21.42	59.68	21.28
Preparedness to Encourage Students in Sci./Engineering [Matrix A]	75.22	21.70	78.00	22.50
Class-Level Variables				
Reform-oriented Instructional Objectives	82.48	13.10	81.57	12.86
Reform-oriented Teaching Practices	61.28	13.85	59.18	13.05
Class size	24.06	5.88	22.42	7.01
Percent Non-Asian Minority Students	37.36	31.90	30.34	29.66
Adequacy of Resources for Science Instruction	59.81	26.45	68.00	23.65
Extent Quality of IT is Problematic [Matrix A]	31.99	27.12	25.34	22.63
Curriculum Control [Matrix B]	36.33	29.05	52.13	30.77
Pedagogical Control [Matrix B]	86.26	18.66	90.23	14.08
Extent Policy Environment Promotes Effective Instruction [Matrix B]	63.59	21.05	60.68	20.25
Extent Stakeholder Support Promotes Effective Instruction [Matrix B]	57.90	25.36	59.90	25.83
Extent School Support Promotes Effective Instruction [Matrix B]	65.79	27.21	64.72	30.47
School Context Variables				
Percent of Students eligible for FRL	44.33	24.56	35.22	21.83
Money Spent per Pupil for Science Instruction	4.65	6.77	8.91	11.14
Supportive Context for Science Instruction	64.24	21.69	63.68	19.38
Extent Lack of Materials/Supplies is Problematic	32.96	27.17	33.70	25.62
Extent Student Issues Are Problematic	40.32	24.27	44.49	24.18
Extent Lack of Time for Science is Problematic	35.87	27.57	36.29	26.03