# Unequal Distribution of Resources for K–12 Science Instruction:

# Data from the 2012 National Survey of Science and Mathematics Education

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# INTRODUCTION

Students' science education is shaped by a number of factors. As many have documented, social inequalities originating outside schools have consequences for students' classroom-based learning and achievement (e.g., Rothstein, 2004; Duncan & Murnane, 2011). Schools, once thought to "level the playing field" by providing equal learning opportunities for students of all backgrounds, are themselves unequally resourced in terms of well-prepared teachers, material supplies for science instruction, science course offerings, and teachers' pedagogical strategies. Historically, the unequal distribution of these resources has resulted in inequitable learning opportunities and outcomes for different groups of students (e.g., Oakes, Ormseth, Bell, & Camp, 1990; Campbell, Hombo, & Mazzeo, 2000).

The 2012 National Survey of Science and Mathematics Education (NSSME) provides a rich source of data for examining the current status of K–12 science and mathematics education, including the extent to which educational opportunities are equitably available. For example, the study collected data on student enrollment in various high school science courses. Disaggregating the data by course type shows that females are more likely than males to be enrolled in advanced courses; however, students historically underrepresented in STEM[1,2] are overrepresented in non-college prep courses, and underrepresented in advanced science courses (see Table 1).

**Table 1**
**Demographics of Students in High School Science Courses**

| | Percent of Students | |
|---|---|---|
| | **Female** | **Historically Underrepresented in STEM** |
| Overall | 49 (0.8) | 31 (1.2) |
| Non-college prep Courses | 46 (1.2) | 36 (2.3) |
| 1st Year Biology | 49 (1.6) | 33 (2.7) |
| 1st Year Chemistry | 51 (1.4) | 30 (1.8) |
| 1st Year Physics | 49 (1.8) | 23 (2.7) |
| Advanced Science Courses | 54 (1.9) | 21 (2.3) |

Similarly, the study found that elementary and high school classes with 40 percent or more of students historically underrepresented in STEM are more likely than classes with smaller proportions of these students to be composed of students classified as low achievers (see Table 2[3]). For example, 24 percent of high school classes composed of 40 percent or more historically

[1] STEM stands for science, technology, engineering, and mathematics.

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

[3] Throughout this paper, we alert the reader to statistically significant differences in two ways. First, cell shading indicates that a significant difference exists. Second, a corresponding table note explicitly states the difference.

underrepresented students are classified as being mostly low achievers, compared to only 6 percent of high school classes composed of less than 10 percent historically underrepresented students.

**Table 2**
**Ability Grouping in Grade K–12 Science Classes with Low, Medium, and High Percentages of Students Historically Underrepresented in STEM**

| | Percent of Classes | | | |
|---|---|---|---|---|
| | **Mostly Low Achievers** | **Mostly Average Achievers** | **Mostly High Achievers** | **A Mixture of Levels** |
| **Elementary**[1] | | | | |
| < 10% Historically Underrepresented | 6 (2.0) | 38 (4.1) | 10 (2.8) | 46 (4.1) |
| 10–39% Historically Underrepresented | 8 (2.7) | 38 (3.0) | 11 (2.3) | 43 (3.5) |
| ≥ 40% Historically Underrepresented | 13 (2.0) | 36 (2.4) | 5 (1.6) | 45 (2.7) |
| **Middle** | | | | |
| < 10% Historically Underrepresented | 13 (5.3) | 37 (4.5) | 12 (2.5) | 39 (5.3) |
| 10–39% Historically Underrepresented | 5 (1.1) | 32 (3.4) | 19 (3.4) | 45 (3.8) |
| ≥ 40% Historically Underrepresented | 26 (4.0) | 29 (2.5) | 9 (1.6) | 36 (4.4) |
| **High**[2] | | | | |
| < 10% Historically Underrepresented | 6 (1.2) | 22 (1.9) | 43 (2.4) | 29 (2.4) |
| 10–39% Historically Underrepresented | 10 (1.4) | 31 (2.3) | 29 (2.4) | 30 (2.3) |
| ≥ 40% Historically Underrepresented | 24 (2.9) | 33 (2.7) | 13 (2.1) | 30 (2.6) |

1 The difference between elementary classes composed of ≥ 40% historically underrepresented students and those composed < 10% historically underrepresented students is significant (two-tailed z-test; $p < 0.05$).

2 The difference between high school classes composed of ≥ 40% historically underrepresented students and those composed < 10% historically underrepresented students is significant (two-tailed z-test; $p < 0.05$).

In this paper, we highlight ways that data from the 2012 NSSME can be used to examine issues of equity in science and mathematics education, focusing on how three important educational resources—well-prepared teachers, material resources, and the nature of instruction (course offerings and instructional strategies)—are currently distributed among K–12 science classrooms in the United States. The following sections describe the three resources and provide historical justification for this line of inquiry.

## Well-Prepared Teachers

The 2012 NSSME collected data on a number of indicators of teacher preparedness, including number of years of teaching experience, professional preparation, and perception of preparedness to teach the science content. Prior data indicate that well-prepared teachers—that is, teachers with five or more years of teaching experience, an educational background in the content area taught, and/or who feel qualified to teach that science content—typically teach in suburban schools (Langford, Loeb, & Wyckoff, 2002; National Center for Education Statistics [NCES], 2012). Beginning teachers and teachers with weaker science backgrounds tend to teach in urban schools (Barton, 2007) and rural schools (Oliver, 2007). An examination of teacher distribution among schools grouped by percentage of students eligible for free or reduced-price lunch (FRL) reveals similar disparities (Zumwalt & Craig, 2005). Schools with lower percentages of students historically underrepresented in STEM typically have higher percentages of well-prepared teachers than schools with higher percentages of students historically underrepresented in STEM (Darling-Hammond, 2004, 2006; Lu, Shen, & Poppink, 2007). Overall, history shows that well-prepared teachers have tended to teach in low-poverty, suburban schools with high percentages of white students.

## Material Resources

Material resources associated with science learning opportunities include the school facilities (e.g., laboratory space), science curriculum materials, and laboratory equipment/supplies (microscopes, chemicals, etc.). Historically, schools in urban and rural settings have tended to have fewer resources than schools in suburban settings (Oakes, et al. 1990; Roscigno, Tomaskovic-Devey, & Crowley, 2006). Also, schools with a high percentage of students qualifying for FRL and/or a high percentage of students historically underrepresented in STEM have tended to have fewer material resources (Hewson, Kahle, Scantlebury, & Davies, 2001; Spillane, Diamond, Walker, Halverson, & Jita, 2001; Lee, Maerten-Rivera, Buxton, Penfield, & Secada, 2009). Inequities in science teaching and allocation of material resources among schools have likely arisen from interrelationships among school setting, student poverty levels, and student body racial/ethnic makeup (Oakes, 1990; Hochschild, 2003).

## Science Instruction

The types and levels of science courses offered by schools and teachers' instructional objectives and practices are key elements of science learning opportunities. In this study, measures of science instruction included instructional time for science and teaching practices: reform-oriented science teaching practices (e.g., engaging in project-based learning activities, requiring students to supply evidence in support of their claims) and traditional science teaching practices (e.g., practicing for standardized tests, having students read from a science textbook). Historically, urban and rural schools have had fewer science course offerings than suburban schools (Coley, 1999). Similarly, higher-poverty schools have tended to have fewer science course offerings than more affluent schools (Gollub, Bertenthal, Labov, & Curtis, 2002). Schools with low percentages of students historically underrepresented in STEM have tended to offer more advanced science courses (e.g., Advanced Placement) than schools with higher percentages of students historically underrepresented in STEM (Gamoran, 1987).

Classroom teaching practices reflect similar patterns. Studies have shown that teachers in urban schools tend to have more constraints on science instructional time, and tend to employ traditional science teaching methods (Barton, 2007). Teachers in high-poverty schools tend to use fewer reform-oriented science teaching methods (Supovitz & Turner, 2000), and more traditional teaching practices, associating high-poverty schools with the "pedagogy of poverty" (Haberman, 1991). Overall, a greater range of science course offerings and reform-oriented science teaching practices have tended to be associated more frequently with affluent, mostly white, suburban schools, whereas traditional science teaching practices and fewer science course offerings have tended to be associated with poorer schools that have higher percentages of students historically underrepresented in STEM.

## STUDY DESIGN

The 2012 NSSME—the fifth in a series of surveys to teachers and science program heads— is based on data from a national probability sample of approximately 10,000 science and mathematics teachers in grades K–12 in public and private schools in the 50 states and the District of Columbia. The sample was designed to allow nationally representative estimates of science and mathematics education indicators, including teacher background and instructional practices. Sample design involved clustering and stratification by elementary or secondary level, then by subject taught, and then selecting a national probability sample. Teachers in self-contained classrooms, most of them elementary teachers, were randomly assigned to either science or mathematics and received a subject-specific questionnaire. In-depth data about curriculum and instruction in a single class were obtained from each teacher (for non-self-contained teachers, a single class was randomly selected for the basis of these questions). The final response rates for school program questionnaires and teacher questionnaires were 83 percent and 77 percent, respectively.[4]

## DATA ANALYSES AND FINDINGS

For this paper, we examined data from the 2012 NSSME by five factors historically associated with differences in students' educational opportunities. The factors fall into two categories, those associated with the randomly selected class teachers responded about, and those associated with school characteristics.

**Class-level factors**

- ***Prior achievement level of the class*—**based on teacher-provided information, classes were coded into one of three categories: mostly low achievers, mostly average achievers/a mixture of levels, or mostly high achievers.
- ***Percent of students historically underrepresented in STEM in the class*—**classes were assigned to quartiles based on the percentage of historically underrepresented students enrolled.

**School-level factors**

- ***Percent of students in the school eligible for free/reduced-price lunch (FRL)*—**each school was classified into one of four categories based on the proportion of students eligible for FRL. Defining common categories across grades K–12 would have been misleading, because students tend to select out of the FRL program as they advance in grade due to perceived social stigma. Therefore, the categories were defined as quartiles

[4] 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/

within groups of schools serving the same grades (e.g., schools with grades K–5, schools with grades 6–8).

- ***School size***—schools were classified into one of four categories based on the number of students served in the school. Like FRL, the categories were defined as quartiles within groups of schools serving the same grades (e.g., schools with grades K–5, schools with grades 6–8).
- ***Community type***—each sample school was classified as belonging to one of three types of communities: Urban (central city); Suburban (area surrounding a central city, but still located within the counties constituting a Metropolitan Statistical Area); or Rural (area outside any Metropolitan Statistical Area).

It is important to note that, to varying degrees, these factors are correlated. For example, classes containing higher proportions of students historically underrepresented in STEM are more likely to be located in schools with higher proportions of FRL students (in addition to being more likely to be classified as low achieving). Urban schools tend to be larger, and have higher proportions of FRL and historically underrepresented students, than suburban or rural schools.

Still, each factor provides a different lens for examining the data, and different researchers may have more interest in some of these factors than others. Although the 2012 NSSME was not designed, primarily, to be an equity study, it provides a rich source of data that researchers can mine to investigate this important issue. Our hope is that, by sharing the types of data available from the study, and demonstrating some of the ways one can examine the data, other researchers will be motivated to conduct secondary analyses of these data.

It is also worth noting that the results presented in this paper show a number of areas where inequities are clear, as well as areas where inequities are not obvious. Readers should keep in mind the strengths and limitations of questionnaire data when interpreting both types of results.

## Well-Prepared Teachers

Of all the resources that factor into students' science education experience, surely teachers are among the most important. As can be seen in Table 3, the vast majority of science teachers at the elementary level are female, decreasing as grade level increases to roughly half at the high school level. In contrast, the teacher experience data are striking in their similarity by subject and grade range.

Teachers from race/ethnic groups historically underrepresented in STEM are also underrepresented in the science and mathematics teaching force. In addition, at a time when only 62 percent of the K–12 student enrollment is White and non-Hispanic, roughly 90 percent of science/mathematics teachers in each grade range characterize themselves that way.

**Table 3**
**Characteristics of the Science Teaching Force, by Grade Range**

| | Percent of Teachers | | |
|---|---|---|---|
| | **Elementary** | **Middle** | **High** |
| **Sex** | | | |
| Male | 6 (0.8) | 30 (2.0) | 46 (1.4) |
| Female | 94 (0.8) | 70 (2.0) | 54 (1.4) |
| **Race** | | | |
| White | 91 (1.5) | 90 (1.4) | 92 (0.8) |
| Black or African-American | 5 (1.1) | 6 (1.2) | 3 (0.5) |
| Hispanic or Latino | 8 (1.4) | 5 (1.0) | 4 (0.6) |
| Asian | 2 (0.4) | 2 (0.8) | 2 (0.5) |
| American Indian/Alaskan Native | 1 (0.3) | 0 (0.2) | 0 (0.2) |
| Native Hawaiian/Other Pacific Islander | 0 (0.2) | 0 (0.1) | 0 (0.2) |
| Two or more races | 1 (0.4) | 1 (0.3) | 2 (0.4) |
| **Experience Teaching Science at the K–12 Level** | | | |
| 0–2 years | 16 (1.4) | 14 (1.7) | 13 (1.1) |
| 3–5 years | 17 (1.6) | 19 (1.8) | 15 (1.2) |
| 6–10 years | 21 (1.5) | 26 (2.6) | 23 (1.5) |
| 11–20 years | 28 (1.7) | 26 (2.1) | 31 (1.4) |
| ≥ 21 years | 17 (1.5) | 16 (2.4) | 18 (1.1) |

Data from the 2012 NSSME suggest that well-prepared teachers are distributed unevenly across schools with different student populations. Disparities are apparent both in the amount of experience teachers have and in their professional preparation. Although there are no significant differences in the distribution of experienced teachers based on school size or community type, Table 4 shows that access to experienced teachers is uneven across particular kinds of classes and schools. Classes of mostly low achievers are more likely than classes of mostly high achievers to be taught by teachers with 0–5 years of teaching experience, and classes with the highest percentages of students historically underrepresented in STEM are more likely than those with the lowest percentage to be taught by teachers with 0–5 years of teaching experience. Notably, almost half of all science classes in high-poverty schools (those with the highest percentages of students eligible for FRL) are taught by teachers with 0–5 years of teaching experience, compared to one-quarter of classes in low-poverty schools.

## Table 4
## Science Classes Taught by Teachers with 0–5 Years of Experience Teaching Science, by Equity Factors

| | Percent of Classes |
|---|---|
| **Prior Achievement Level of Class[1]** | |
| Mostly High Achievers | 25 (2.3) |
| Average/Mixed Achievers | 33 (1.3) |
| Mostly Low Achievers | 35 (3.5) |
| **Percent of Historically Underrepresented Students in Class[2]** | |
| Lowest Quartile | 29 (2.9) |
| Second Quartile | 26 (2.3) |
| Third Quartile | 27 (2.2) |
| Highest Quartile | 40 (2.3) |
| **Percent of Students in School Eligible for FRL[3]** | |
| Lowest Quartile | 26 (2.2) |
| Second Quartile | 27 (2.3) |
| Third Quartile | 32 (2.1) |
| Highest Quartile | 45 (3.1) |
| **School Size** | |
| Smallest Schools | 31 (2.1) |
| Second Group | 32 (2.5) |
| Third Group | 32 (2.2) |
| Largest Schools | 30 (2.0) |
| **Community Type** | |
| Rural | 29 (1.9) |
| Suburban | 32 (1.7) |
| Urban | 34 (1.8) |

1 The difference between classes composed of mostly high prior achievers and those composed of mostly low prior achievers is significant (two-tailed z-test; $p < 0.05$).

2 The difference between the highest quartile and lowest quartile of percent of historically underrepresented students in class is significant (two-tailed z-test; $p < 0.05$).

3 The difference between the highest quartile and lowest quartile of percent of students in school eligible for FRL is significant (two-tailed z-test; $p < 0.05$).

Although classes with the highest percentages of students historically underrepresented in STEM are considerably more likely than those with the lowest percentages to be taught by teachers of similar background (see Table 5), the odds of these students having a science teacher of the same race/ethnicity are quite low.

## Table 5
## Science Classes Taught by Teachers from Historically Underrepresented Race/Ethnic Groups, by Proportion of Historically Underrepresented Students in Class[1]

| | Percent of Classes |
|---|---|
| Lowest Quartile of Historically Underrepresented Students | 3 (0.8) |
| Second Quartile of Historically Underrepresented Students | 3 (0.9) |
| Third Quartile of Historically Underrepresented Students | 7 (1.0) |
| Highest Quartile of Historically Underrepresented Students | 34 (2.5) |

1 The difference between the highest quartile and lowest quartile of percent of historically underrepresented students in class is significant (two-tailed z-test; $p < 0.05$).

In order to help students learn science/mathematics content, teachers must themselves have a firm grasp of the important ideas in the discipline. As seen in Table 6, over half of secondary teachers (middle and high school) across all schools have a college or graduate degree in science or science education, and there are no significant differences in percentages of teachers with such degrees by school size or community type. However, science teachers in schools with the highest percentages of students eligible for FRL are less likely than teachers in schools with the lowest percentage to have a science/science education degree.

**Table 6**
**Secondary Teachers with a Degree in**
**Science or Science Education, by Equity Factors**

| | Percent of Teachers | |
|---|---|---|
| **Percent of Students in School Eligible for FRL[1]** | | |
| Lowest Quartile | 68 | (3.1) |
| Second Quartile | 57 | (3.3) |
| Third Quartile | 62 | (3.7) |
| Highest Quartile | 58 | (3.9) |
| **School Size** | | |
| Smallest Schools | 60 | (3.3) |
| Second Group | 64 | (3.5) |
| Third Group | 63 | (3.1) |
| Largest Schools | 62 | (3.9) |
| **Community Type** | | |
| Rural | 59 | (2.8) |
| Suburban | 63 | (2.3) |
| Urban | 63 | (3.8) |

[1] The difference between the highest quartile and lowest quartile of percent of students in school eligible for FRL is significant (two-tailed z-test; $p < 0.05$).

Table 7 shows the mean scores on each of several teacher preparedness composites[5] for science classes categorized by the equity factors. The composite variables are listed below, with the items that each one includes.

**Perceptions of Preparedness to Teach Students from Diverse Backgrounds**

1. Plan instruction so students at different levels of achievement can increase their understanding of the ideas targeted in each activity
2. Teach science to students who have learning disabilities
3. Teach science to students who have physical disabilities
4. Teach science to English-language learners
5. Provide enrichment experiences for gifted students

**Perceptions of Preparedness to Encourage Students' Interest in Science/Engineering**

1. Encourage students' interest in science and/or engineering
2. Encourage participation of females in science and/or engineering
3. Encourage participation of racial or ethnic minorities in science and/or engineering
4. Encourage participation of students from low socioeconomic backgrounds in science and/or engineering

[5] Composite variables were created through factor analysis of the survey items. For a full description of the composite variables, please see the Report of the 2012 National Survey of Science and Mathematics Education (http://www.horizon-research.com/2012nssme/research-products/reports/technical-report/).

**Perceptions of Preparedness to Implement Instruction in a Particular Unit**

1. Anticipate difficulties that students will have with particular science ideas and procedures in this unit
2. Find out what students thought or already knew about the key science ideas
3. Implement the science textbook/module to be used during this unit
4. Monitor student understanding during this unit
5. Assess student understanding at the conclusion of this unit

For the **Perceptions of Preparedness to Teach Science Content** composite, teachers of non-self-contained classes were asked about topics related to a randomly selected class. For example, Earth Science teachers were asked about their preparedness to teach about:

1. Earth's features and physical processes
2. The solar system and the universe
3. Climate and weather

The most striking differences in these composites are among classes of students with different levels of prior achievement. Classes of mostly low-achieving students are less likely than classes of mostly high-achieving students to be taught by teachers who feel well prepared to teach students from diverse backgrounds, encourage students' interest in science, teach science content, and implement instruction in a particular unit. In addition, classes with the highest percentages of students historically underrepresented in STEM and classes in schools with the highest percentages of students eligible for FRL are less likely to be taught by teachers who feel well prepared to encourage students' interest in science. Furthermore, classes in schools with the highest percentages of students eligible for FRL are less likely than classes in schools with the lowest percentage of these students to be taught by teachers who feel well prepared to teach students from diverse backgrounds.

## Table 7
## Class Mean Scores for Science Teachers' Perceptions of Preparedness Composites, by Equity Factors

| | Mean Score | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Teach Students from Diverse Backgrounds | | Encourage Students' Interest in Science | | Teach Science Content† | | Implement Instruction in a Particular Unit | |
| **Prior Achievement Level of Class[1]** | | | | | | | | |
| Mostly High Achievers | 57 | (1.8) | 80 | (1.3) | 83 | (1.1) | 84 | (1.0) |
| Average/Mixed Achievers | 56 | (1.0) | 69 | (1.2) | 79 | (0.8) | 77 | (0.5) |
| Mostly Low Achievers | 51 | (2.5) | 65 | (2.8) | 73 | (3.7) | 75 | (1.1) |
| **Percent of Historically Underrepresented Students in Class[2]** | | | | | | | | |
| Lowest Quartile | 54 | (1.8) | 72 | (1.8) | 79 | (1.6) | 80 | (1.0) |
| Second Quartile | 54 | (1.6) | 70 | (1.7) | 81 | (1.0) | 79 | (0.9) |
| Third Quartile | 57 | (1.4) | 72 | (1.5) | 80 | (1.1) | 79 | (0.9) |
| Highest Quartile | 55 | (1.4) | 65 | (2.4) | 79 | (1.7) | 76 | (1.0) |
| **Percent of Students in School Eligible for FRL[3]** | | | | | | | | |
| Lowest Quartile | 60 | (2.0) | 74 | (1.9) | 81 | (1.0) | 79 | (1.0) |
| Second Quartile | 57 | (1.5) | 70 | (1.8) | 80 | (1.1) | 80 | (0.6) |
| Third Quartile | 54 | (1.4) | 67 | (2.8) | 79 | (1.3) | 76 | (0.9) |
| Highest Quartile | 54 | (1.7) | 68 | (1.6) | 80 | (1.7) | 76 | (1.1) |
| **School Size[4]** | | | | | | | | |
| Smallest Schools | 55 | (1.6) | 70 | (1.7) | 77 | (2.0) | 78 | (0.9) |
| Second Group | 53 | (1.7) | 68 | (2.1) | 81 | (1.1) | 77 | (1.1) |
| Third Group | 59 | (1.3) | 73 | (1.6) | 80 | (1.1) | 79 | (0.9) |
| Largest Schools | 56 | (1.2) | 69 | (2.4) | 81 | (1.8) | 78 | (0.9) |
| **Community Type** | | | | | | | | |
| Rural | 54 | (1.4) | 69 | (1.8) | 79 | (1.0) | 79 | (0.9) |
| Suburban | 57 | (1.3) | 71 | (1.4) | 80 | (1.0) | 79 | (0.6) |
| Urban | 55 | (1.3) | 70 | (2.3) | 79 | (2.1) | 76 | (1.1) |

† Perceptions of Preparedness to Teach Science Content score was computed only for non-self-contained classes and is based on content in the randomly selected class.

1 The differences between classes composed of mostly high prior achievers and those composed of mostly low prior achievers are significant for all four composites (two-tailed z-test; $p < 0.05$).

2 The differences between the highest quartile and lowest quartile of percent of historically underrepresented students in class are significant for the Perceptions of Preparedness to Encourage Students' Interest in Science and Perceptions of Preparedness to Implement Instruction in Particular Unit composites (two-tailed z-test; $p < 0.05$).

3 The differences between the highest quartile and lowest quartile of percent of students in school eligible for FRL are significant for the Perceptions of Preparedness to Teach Students from Diverse Backgrounds, Perceptions of Preparedness to Encourage Students' Interest in Science, and Perceptions of Preparedness to Implement Instruction in Particular Unit composites (two-tailed z-test; $p < 0.05$).

4 The difference between the largest schools and the smallest schools is significant for the Perceptions of Preparedness to Teach Science Content composite (two-tailed z-test; $p < 0.05$).

Another measure of preparedness is the extent to which teachers participate in professional development. Table 8 shows the extent to which science classes with different characteristics are taught by teachers who have participated in more than 35 hours of professional development in the last three years. Classes with varying percentages of students historically underrepresented in STEM and classes in schools with varying percentages of students eligible for FRL are equally likely to have teachers who participated in substantial professional development. However, classes of mostly high achievers are more likely to be taught by such teachers than classes of mostly low achievers.

**Table 8**
**Classes Taught by Science Teachers with More than 35 Hours of Professional Development in the Last Three Years, by Equity Factors**

| | Percent of Classes | |
|---|---|---|
| **Prior Achievement Level of Class[1]** | | |
| Mostly High Achievers | 33 | (2.6) |
| Average/Mixed Achievers | 19 | (1.0) |
| Mostly Low Achievers | 25 | (2.8) |
| **Percent of Historically Underrepresented Students in Class** | | |
| Lowest Quartile | 20 | (1.9) |
| Second Quartile | 19 | (1.5) |
| Third Quartile | 27 | (2.0) |
| Highest Quartile | 23 | (2.0) |
| **Percent of Students in School Eligible for FRL** | | |
| Lowest Quartile | 23 | (1.8) |
| Second Quartile | 20 | (1.9) |
| Third Quartile | 20 | (2.0) |
| Highest Quartile | 26 | (2.7) |
| **School Size** | | |
| Smallest Schools | 20 | (2.1) |
| Second Group | 19 | (2.1) |
| Third Group | 24 | (1.8) |
| Largest Schools | 25 | (1.9) |
| **Community Type[2]** | | |
| Rural | 22 | (2.2) |
| Suburban | 20 | (1.1) |
| Urban | 27 | (2.1) |

[1] The difference between classes composed of mostly high prior achievers and those composed of mostly low prior achievers is significant (two-tailed z-test; $p < 0.05$).
[2] The difference between suburban and urban is significant (two-tailed z-test; $p < 0.05$).

The amount of professional development a teacher experiences is important, but so is the quality of the experience. Teachers were asked to rate their professional development along six dimensions, which were combined into a single composite variable called "Quality of Professional Development." The six items were:

1. You had opportunities to engage in science investigations.
2. You had opportunities to examine classroom artifacts (e.g., student work samples).
3. You had opportunities to try out what you learned in your classroom and then talk about it as part of the professional development.
4. You worked closely with other science teachers from your school.
5. You worked closely with other science teachers who taught the same grade and/or subject whether or not they were from your school.
6. The professional development was a waste of your time.

As seen in Table 9, classes of mostly low achievers are more likely than classes of mostly high achievers to be taught by teachers who report lower-quality professional development experiences, and science classes in the smallest schools are more likely to be taught by teachers who report lower quality professional development experiences than classes in the largest schools. And although all teachers should experience high-quality professional development, it is somewhat encouraging to note that classes with the highest percentages of students historically underrepresented in STEM are more likely to be taught by teachers who report higher quality professional development experiences than classes with the lowest percentage of students historically underrepresented in STEM.

**Table 9**
**Science Class Mean Scores for the Quality of Professional Development Composite, by Equity Factors**

| | Mean Score |
|---|---|
| **Prior Achievement Level of Class[1]** | |
| Mostly High Achievers | 66 (2.0) |
| Average/Mixed Achievers | 60 (0.9) |
| Mostly Low Achievers | 60 (2.7) |
| **Percent of Historically Underrepresented Students in Class[2]** | |
| Lowest Quartile | 56 (2.0) |
| Second Quartile | 61 (1.7) |
| Third Quartile | 62 (1.5) |
| Highest Quartile | 65 (1.5) |
| **Percent of Students in School Eligible for FRL** | |
| Lowest Quartile | 60 (1.6) |
| Second Quartile | 61 (1.7) |
| Third Quartile | 64 (2.2) |
| Highest Quartile | 62 (1.4) |
| **School Size[3]** | |
| Smallest Schools | 56 (2.1) |
| Second Group | 62 (1.6) |
| Third Group | 63 (1.3) |
| Largest Schools | 63 (1.3) |
| **Community Type** | |
| Rural | 59 (1.8) |
| Suburban | 62 (1.1) |
| Urban | 62 (1.7) |

1 The difference between classes composed of mostly high prior achievers and those composed of mostly low prior achievers is significant (two-tailed z-test; $p < 0.05$).
2 The difference between the highest quartile and lowest quartile of percent of historically underrepresented students in class is significant (two-tailed z-test; $p < 0.05$).
3 The difference between the largest schools and the smallest schools is significant (two-tailed z-test; $p < 0.05$).

There is a growing recognition that professional development can and should occur in forms other than the traditional workshop. Study groups and coaching are two forms that are gaining prominence, as is targeting individualized assistance to teachers identified as needing help. Regardless of school size, community type, or percentage of students eligible for FRL, schools are about equally likely to provide assistance to science teachers in need (see Table 10). In contrast, there is a great deal of variation in the availability of one-on-one science-focused coaching. Schools with the highest percentages of students eligible for FRL are more likely than schools with the lowest percentage to offer one-on-one coaching, and urban schools are more likely than schools in suburban or rural areas to offer one-on-one coaching. Additionally, the largest schools are substantially more likely than the smallest schools to offer one-on-one coaching. There is also a significant difference in the prevalence of science-focused study groups based on school size. The largest schools are more likely to offer these study groups than the smallest schools, likely due to the larger numbers of science teachers they employ.

**Table 10**
**Schools Providing Various Services to Science Teachers, by Equity Factors**

| | Percent of Schools | | | | | |
|---|---|---|---|---|---|---|
| | Science-Focused Study Groups | | One-on-One Science-Focused Coaching | | Assistance to Science Teachers in Need† | |
| **Percent of Students in School Eligible for FRL[1]** | | | | | | |
| Lowest Quartile | 34 | (4.7) | 16 | (3.1) | 81 | (4.0) |
| Second Quartile | 34 | (4.1) | 17 | (3.9) | 78 | (3.3) |
| Third Quartile | 49 | (4.0) | 18 | (2.6) | 79 | (3.6) |
| Highest Quartile | 40 | (4.2) | 28 | (3.8) | 86 | (3.0) |
| **School Size[2]** | | | | | | |
| Smallest Schools | 35 | (4.6) | 14 | (2.4) | 82 | (2.8) |
| Second Group | 41 | (4.2) | 21 | (3.0) | 80 | (3.3) |
| Third Group | 41 | (4.1) | 24 | (3.1) | 83 | (3.5) |
| Largest Schools | 49 | (3.9) | 30 | (4.1) | 81 | (3.8) |
| **Community Type[3]** | | | | | | |
| Rural | 42 | (4.4) | 11 | (2.2) | 80 | (3.1) |
| Suburban | 38 | (3.2) | 20 | (2.1) | 83 | (2.3) |
| Urban | 38 | (4.0) | 30 | (2.8) | 80 | (3.7) |

† Assistance defined as guidance from a formally designated mentor or coach; seminars, classes, and/or study groups; or a higher level of supervision than for other teachers.
1 The difference between the highest quartile and lowest quartile of percent of students in school eligible for FRL is significant for One-on-One Science-Focused Coaching (two-tailed z-test; $p < 0.05$).
2 The differences between the largest schools and the smallest schools are significant for Science-Focused Study Groups and One-on-One Science-Focused Coaching (two-tailed z-test; $p < 0.05$).
3 The difference between each pair of community types is significant for One-on-One Science-Focused Coaching (two-tailed z-test; $p < 0.05$).

## Material Resources

Material resources for science instruction can be thought of in terms of both availability and adequacy. Availability is a measure of the presence of resources, but not necessarily the quality or the necessity. A school with widespread availability of aging and unreliable computers may be no better off than a school with no computers. Conversely, lack of availability does not necessarily signal a problem for instruction in a particular class. For example, physics teachers rarely if ever need microscopes. The 2012 NSSME included several questions about the availability and adequacy of materials, as well as questions about how problematic resources are for instruction.

The most general items about material resources asked science teachers to rate the adequacy of their equipment, instructional technology, consumable supplies, and facilities. These four items were combined into a composite variable titled, "Adequacy of Resources for Science Instruction." As shown in Table 11, perceptions of the resource adequacy vary substantially by grade level, with teachers of high school classes much more likely than elementary teachers to give high ratings. An analysis by each of the equity factors indicates that students already at a disadvantage, whether due to prior achievement, race/ethnicity, or poverty, are in settings that are under-resourced (see Table 12).

**Table 11**
**Class Mean Scores on the Adequacy of Resources for Science Instruction Composite, by Grade Range**

| | Mean Score[1] |
|---|---|
| Elementary School | 49 (1.4) |
| Middle School | 57 (1.4) |
| High School | 68 (0.9) |

[1] The differences between high school classes and elementary school classes, between high school classes and middle school classes, and between elementary school classes and middle school classes are significant (two-tailed z-test; $p < 0.05$).

**Table 12**
**Class Mean Scores on the Adequacy of Resources for Science Instruction Composite, by Equity Factors**

| | Mean Score |
|---|---|
| **Prior Achievement Level of Class[1]** | |
| Mostly High Achievers | 69 (1.6) |
| Average/Mixed Achievers | 56 (0.9) |
| Mostly Low Achievers | 47 (2.4) |
| **Percent of Historically Underrepresented Students in Class[2]** | |
| Lowest Quartile | 60 (1.5) |
| Second Quartile | 59 (1.5) |
| Third Quartile | 58 (1.3) |
| Highest Quartile | 50 (1.7) |
| **Percent of Students in School Eligible for FRL[3]** | |
| Lowest Quartile | 64 (1.7) |
| Second Quartile | 55 (1.4) |
| Third Quartile | 54 (1.5) |
| Highest Quartile | 50 (1.7) |
| **School Size** | |
| Smallest Schools | 55 (1.8) |
| Second Group | 57 (1.5) |
| Third Group | 57 (1.6) |
| Largest Schools | 57 (1.7) |
| **Community Type** | |
| Rural | 54 (1.5) |
| Suburban | 58 (1.1) |
| Urban | 57 (1.7) |

[1] The difference between classes composed of mostly high prior achievers and those composed of mostly low prior achievers is significant (two-tailed z-test; $p < 0.05$).
[2] The difference between the highest quartile and lowest quartile of percent of historically underrepresented students in class is significant (two-tailed z-test; $p < 0.05$).
[3] The difference between the highest quartile and lowest quartile of percent of students in school eligible for FRL is significant (two-tailed z-test; $p < 0.05$).

Science teachers were also asked to indicate the availability of various instructional technologies. Table 13 shows the percentage of classes, by grade level, in which these technologies are available; i.e., one per small group (4–5 students). Clearly, some technologies are more widely available in general than others (e.g., non-graphing vs. graphing calculators). In addition, there is variation by grade level, some of which is to be expected. Microscopes, for example, are available in greater percentage of secondary classes than elementary classes, likely due to the sophistication of science activities in secondary grades.

**Table 13**
**Availability† of Instructional Technologies in Science Classes, by Grade Range**

| | Percent of Classes | | | | | |
|---|---|---|---|---|---|---|
| | Elementary | | Middle | | High | |
| Microscopes[1] | 48 | (3.2) | 82 | (1.9) | 81 | (1.9) |
| Non-graphing calculators[2] | 69 | (2.9) | 83 | (2.3) | 77 | (2.1) |
| Probes for collecting data (e.g., motion sensors, temperature probes)[3] | 32 | (3.1) | 43 | (2.9) | 64 | (2.5) |
| Graphing calculators[4] | 9 | (2.3) | 30 | (2.9) | 44 | (2.3) |

† Includes only those rating the availability as at least one per group available, either in the classroom, upon request, or in another room.
1 The differences between elementary and middle and elementary and high are significant (two-tailed z-test; $p < 0.05$).
2 The differences between elementary and middle and elementary and high are significant (two-tailed z-test; $p < 0.05$).
3 The differences between each pair of grade ranges are significant (two-tailed z-test; $p < 0.05$).
4 The differences between each pair of grade ranges are significant (two-tailed z-test; $p < 0.05$).

Access to some of these technologies is uneven across different kinds of classes and schools. As can be seen in Table 14, classes of mostly high-achieving students are substantially more likely than those of mostly low-achieving students to have access to each of the technologies. Classes with the lowest percentage of students historically underrepresented in STEM are substantially more likely than those with the highest percentage to have access to non-graphing calculators, and classes in schools with the lowest percentage of FRL students are more likely than those in schools with the highest percentages of these students to have access to microscopes. Interestingly, availability of these technologies is quite consistent regardless of community type.

**Table 14**
**Availability† of Instructional Technologies in Science Classes, by Equity Factors**

| | Percent of Classes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Graphing Calculators | | Non-Graphing Calculators | | Probes For Collecting Data | | Microscopes | |
| **Prior Achievement Level of Class[1]** | | | | | | | | |
| Mostly High Achievers | 39 | (3.6) | 79 | (3.3) | 58 | (4.7) | 82 | (3.0) |
| Average/Mixed Achievers | 23 | (1.5) | 77 | (1.6) | 43 | (2.1) | 63 | (2.0) |
| Mostly Low Achievers | 18 | (3.3) | 61 | (6.0) | 34 | (4.4) | 59 | (5.1) |
| **Percent of Historically Underrepresented Students in Class[2]** | | | | | | | | |
| Lowest Quartile | 31 | (3.1) | 84 | (2.3) | 46 | (4.0) | 63 | (3.5) |
| Second Quartile | 25 | (2.7) | 78 | (2.4) | 47 | (3.4) | 67 | (3.6) |
| Third Quartile | 17 | (2.1) | 79 | (3.9) | 43 | (3.3) | 72 | (2.8) |
| Highest Quartile | 23 | (3.3) | 65 | (3.5) | 39 | (3.2) | 57 | (3.9) |
| **Percent of Students in School Eligible for FRL[3]** | | | | | | | | |
| Lowest Quartile | 22 | (2.4) | 73 | (4.5) | 48 | (3.8) | 73 | (2.7) |
| Second Quartile | 22 | (2.7) | 80 | (3.2) | 39 | (3.8) | 68 | (3.2) |
| Third Quartile | 27 | (3.6) | 79 | (2.5) | 48 | (3.5) | 63 | (3.2) |
| Highest Quartile | 24 | (2.8) | 70 | (3.3) | 41 | (3.4) | 60 | (3.9) |
| **School Size[4]** | | | | | | | | |
| Smallest Schools | 32 | (3.1) | 81 | (3.0) | 48 | (3.0) | 66 | (3.2) |
| Second Group | 19 | (2.4) | 75 | (3.3) | 38 | (3.6) | 67 | (3.4) |
| Third Group | 23 | (2.4) | 75 | (2.8) | 50 | (3.4) | 67 | (3.6) |
| Largest Schools | 25 | (3.4) | 70 | (3.2) | 41 | (3.5) | 62 | (3.6) |
| **Community Type[5]** | | | | | | | | |
| Rural | 27 | (2.7) | 80 | (2.4) | 43 | (3.5) | 68 | (2.9) |
| Suburban | 24 | (1.7) | 76 | (2.4) | 44 | (2.5) | 63 | (2.1) |
| Urban | 23 | (3.2) | 70 | (2.9) | 45 | (3.3) | 68 | (3.2) |

† Availability defined as having at least one instructional technology per small group (4–5 students).
1 The differences between classes composed of mostly high prior achievers and those composed of mostly low prior achievers are significant for all four instructional technologies (two-tailed z-test; $p < 0.05$).
2 The differences between the highest quartile and lowest quartile of percent of historically underrepresented students in class are significant for graphing calculators and non-graphing calculators (two-tailed z-test; $p < 0.05$).
3 The difference between the highest quartile and lowest quartile of percent of students in school eligible for FRL is significant for microscopes (two-tailed z-test; $p < 0.05$).
4 The difference between the largest schools and the smallest schools is significant for non-graphing calculators (two-tailed z-test; $p < 0.05$).
5 The difference between rural and urban is significant for non-graphing calculators (two-tailed z-test; $p < 0.05$).

As noted above, unavailability of resources may not hinder instruction. To get a more accurate picture of the influence on classroom practice, science teachers were asked to rate the extent to which several factors related to instructional technology posed a problem for their instruction. Factors included:

- Lack of access to computers;
- Old age of computers;
- Unreliability of the Internet connection; and
- Lack of availability of technology support.

A low score on this composite indicates that quality is not problematic. Although differences are significant by the prior achievement level of the class and by the percentage of historically underrepresented students in the class, they are not substantial (see Table 15). Rather, these data suggest that IT quality is not particularly problematic overall, regardless of school and class characteristics.

**Table 15**
**Class Mean Scores on the Extent to Which IT Quality is Problematic for Science Instruction Composite, by Equity Factors**

| | Mean Score |
|---|---|
| **Prior Achievement Level of Class**[1] | |
| Mostly High Achievers | 22 (2.1) |
| Average/Mixed Achievers | 23 (1.0) |
| Mostly Low Achievers | 31 (3.5) |
| **Percent of Historically Underrepresented Students in Class**[2] | |
| Lowest Quartile | 22 (1.7) |
| Second Quartile | 24 (1.7) |
| Third Quartile | 22 (1.7) |
| Highest Quartile | 28 (2.2) |
| **Percent of Students in School Eligible for FRL** | |
| Lowest Quartile | 25 (1.8) |
| Second Quartile | 23 (1.5) |
| Third Quartile | 23 (1.7) |
| Highest Quartile | 28 (2.4) |
| **School Size** | |
| Smallest Schools | 24 (1.9) |
| Second Group | 23 (1.7) |
| Third Group | 23 (1.7) |
| Largest Schools | 27 (2.1) |
| **Community Type** | |
| Rural | 24 (1.6) |
| Suburban | 24 (1.1) |
| Urban | 25 (2.3) |

[1] The difference between classes composed of mostly high prior achievers and those composed of mostly low prior achievers is significant (two-tailed z-test; $p < 0.05$).
[2] The difference between the highest quartile and lowest quartile of percent of historically underrepresented students in class is significant (two-tailed z-test; $p < 0.05$).

## Science Instruction

Science instruction can be thought of as a resource to which students have varying degrees of access. The survey asked science teachers and science program representatives to respond to several questions about instruction and whether students have access to rigorous science courses. In order to increase the precision of their responses, teachers were asked to respond for a particular class (as opposed to their science instruction overall) and in some instances, for their most recent lesson in that class. This section of the paper presents findings that shed light on how science instruction, as a resource, is related to school- and class-level equity-related factors.

Self-contained elementary teachers were asked how often they teach the four core subjects: reading, mathematics, science, and social studies. As can be seen in Table 16, grade K–3 self-contained classes spent an average of 89 minutes per day on reading instruction and 54 minutes on mathematics instruction, compared to only 19 minutes on science and 16 minutes on social studies instruction. The pattern in grades 4–6 is similar, with 83 minutes per day devoted to reading, 61 minutes to mathematics, 24 minutes to science, and 21 minutes to social studies instruction.

**Table 16**
**Average Number of Minutes per Day Spent**
**Teaching Each Subject in Self-Contained Classes,[†] by Grades**

| | Number of Minutes | |
|---|---|---|
| | **Grades K–3** | **Grades 4–6** |
| Reading/Language Arts | 89 (1.7) | 83 (2.2) |
| Mathematics | 54 (1.0) | 61 (1.4) |
| Science | 19 (0.5) | 24 (0.9) |
| Social Studies | 16 (0.4) | 21 (0.8) |

† Only teachers who indicated they teach reading/language arts, mathematics, science, and social studies to one class of students were included in these analyses.

Within science, time spent on instruction is similar regardless of community type, school size, percentage of students in school eligible for FRL, percentage students historically underrepresented in STEM in the class, and student prior achievement level (see Table 17).

**Table 17**
**Average Number of Minutes per Day Spent**
**Teaching Science in Self-Contained Classes[†], by Equity Factors**

| | **Average Minutes per Day** |
|---|---|
| **Prior Achievement Level of Class** | |
| Mostly High Achievers | 22 (1.1) |
| Average/Mixed Achievers | 20 (0.5) |
| Mostly Low Achievers | 21 (1.7) |
| **Percent of Historically Underrepresented Students in Class** | |
| Lowest Quartile | 19 (0.9) |
| Second Quartile | 19 (0.8) |
| Third Quartile | 20 (0.9) |
| Highest Quartile | 21 (0.8) |
| **Percent of Students in School Eligible for FRL** | |
| Lowest Quartile | 21 (1.0) |
| Second Quartile | 19 (0.8) |
| Third Quartile | 21 (0.9) |
| Highest Quartile | 19 (1.1) |
| **School Size** | |
| Smallest Schools | 20 (1.0) |
| Second Group | 18 (0.9) |
| Third Group | 20 (0.9) |
| Largest Schools | 21 (0.9) |
| **Community Type** | |
| Rural | 18 (0.8) |
| Suburban | 20 (0.7) |
| Urban | 21 (0.8) |

† Only teachers who indicated they teach reading, mathematics, science, and social studies to one class of students were included in these analyses.

At the high school level, science instruction is influenced by the number and types of science course offerings. In particular, the number of advanced science course offerings, such as Advanced Placement (AP) Biology, Chemistry, Environmental Science, and Physics courses, provides an indicator of higher-level science learning opportunities for students. Table 18 shows that, on average, schools with the highest percentages of students eligible for FRL tend to offer fewer AP courses than schools with the lowest percentages of students eligible for FRL. Also, on average, the smallest high schools offer fewer AP science courses than the largest high schools. Finally, rural schools average fewer AP course offerings than either urban or suburban schools.

**Table 18**
**Average Number of AP Science Courses Offered at High Schools, by Equity Factors**

| | Average Number of Courses | |
|---|---|---|
| **Percent of Students in School Eligible for FRL[1]** | | |
| Lowest Quartile | 2.0 | (0.2) |
| Second Quartile | 1.5 | (0.3) |
| Third Quartile | 1.1 | (0.2) |
| Highest Quartile | 1.1 | (0.2) |
| **School Size[2]** | | |
| Smallest Schools | 0.7 | (0.1) |
| Second Group | 1.2 | (0.2) |
| Third Group | 2.1 | (0.2) |
| Largest Schools | 2.8 | (0.2) |
| **Community Type[3]** | | |
| Rural | 0.7 | (0.1) |
| Suburban | 1.7 | (0.2) |
| Urban | 1.7 | (0.3) |

1 The difference between the highest quartile and lowest quartile of percent of students in school eligible for FRL is significant (two-tailed z-test; $p < 0.05$).
2 The difference between the largest schools and the smallest schools is significant (two-tailed z-test; $p < 0.05$).
3 The difference between rural and suburban and rural and urban is significant (two-tailed z-test; $p < 0.05$).

Science instruction is also shaped by teachers' instructional objectives and goals. Reform efforts of recent years have highlighted, among other goals, the importance of developing students' conceptual understanding and science process skills. The survey asked teachers about a number of instructional objectives, five of which were combined into a composite titled, "Reform-oriented Instructional Objectives." The items asked how much emphasis instruction gave to:

- understanding science concepts;
- increasing students' interest in science;
- learning science process skills;
- preparing for further study in science; and
- learning about real-life applications of science.

Overall, the mean scores suggest equitable distribution of reform-oriented instructional objectives by the percentage of students historically underrepresented in STEM in the class, school size, and community type (see Table 20). Classes in schools with the lowest percentages of students eligible for FRL are slightly more likely to experience reform-oriented instructional objectives than classes in schools with the highest percentages of students eligible for FRL. Finally, there is a significant difference between composite mean scores for classes composed of mostly low achievers and classes composed of mostly high achievers, with high achievers more likely to experience instruction consistent with reform-oriented instructional objectives.

**Table 20**
**Science Class Mean Scores on the Reform-Oriented Instructional Objectives Composite, by Equity Factors**

| | Mean Score |
|---|---|
| **Prior Achievement Level of Class[1]** | |
| Mostly High Achievers | 86 (0.6) |
| Average/Mixed Achievers | 81 (0.4) |
| Mostly Low Achievers | 77 (1.5) |
| **Percent of Historically Underrepresented Students in Class** | |
| Lowest Quartile | 82 (0.8) |
| Second Quartile | 81 (0.6) |
| Third Quartile | 81 (0.9) |
| Highest Quartile | 80 (0.9) |
| **Percent of Students in School Eligible for FRL[2]** | |
| Lowest Quartile | 84 (0.8) |
| Second Quartile | 80 (0.8) |
| Third Quartile | 81 (0.8) |
| Highest Quartile | 80 (0.9) |
| **School Size** | |
| Smallest Schools | 81 (0.7) |
| Second Group | 81 (0.7) |
| Third Group | 81 (0.8) |
| Largest Schools | 82 (0.9) |
| **Community Type** | |
| Rural | 81 (0.8) |
| Suburban | 81 (0.6) |
| Urban | 81 (0.7) |

[1] The difference between classes composed of mostly high prior achievers and those composed of mostly low prior achievers is significant (two-tailed z-test; $p < 0.05$).

[2] The difference between the highest quartile and lowest quartile of percent of students in school eligible for FRL is significant (two-tailed z-test; $p < 0.05$).

Relatedly, recent and current science education reform movements emphasize science instruction that is characterized by students engaging in authentic science experiences and using technology. The "Reform-oriented Teaching Practices" composite combines several survey items including having students do hands-on/laboratory activities, requiring students to supply evidence in support of their claims, and having students represent and/or analyze data using tables, charts, or graphs. The "Use of Instructional Technology" composite examines the use of various technologies in the service of science instruction: personal computers (including laptops), handheld computers, graphing and non-graphing calculators, Internet, and probes for collecting data.

As can be seen in Table 21, scores on these composites are fairly similar across the various equity factors. Notably, reform-oriented instruction is generally equitably distributed as a function of school size and community type, and as a function of the percentage of historically underrepresented students in the class. There are small, but significant, differences in the use of reform-oriented teaching practices as a function of student prior achievement and the percentage of students in the school eligible for FRL. In addition, classes of mostly high achievers are more likely to experience science instruction that uses technology than classes of mostly low achievers.

**Table 21**
**Class Mean Scores on Science Teaching Practice Composites, by Equity Factors**

| | Mean Score | |
|---|---|---|
| | **Use of Reform-Oriented Teaching Practices** | **Use of Instructional Technology** |
| **Prior Achievement Level of Class[1]** | | |
| Mostly High Achievers | 63 (0.8) | 33 (1.6) |
| Average/Mixed Achievers | 60 (0.4) | 27 (0.8) |
| Mostly Low Achievers | 59 (1.1) | 25 (1.7) |
| **Percent of Historically Underrepresented Students in Class** | | |
| Lowest Quartile | 60 (0.6) | 28 (1.2) |
| Second Quartile | 60 (0.9) | 28 (1.2) |
| Third Quartile | 59 (0.8) | 27 (1.1) |
| Highest Quartile | 61 (0.8) | 25 (1.4) |
| **Percent of Students in School Eligible for FRL[2]** | | |
| Lowest Quartile | 63 (0.8) | 29 (1.0) |
| Second Quartile | 60 (0.9) | 28 (1.3) |
| Third Quartile | 60 (0.6) | 27 (1.4) |
| Highest Quartile | 60 (0.9) | 26 (1.2) |
| **School Size[3]** | | |
| Smallest Schools | 59 (0.9) | 30 (1.1) |
| Second Group | 60 (0.7) | 25 (1.1) |
| Third Group | 61 (0.7) | 28 (1.2) |
| Largest Schools | 61 (0.8) | 27 (1.3) |
| **Community Type** | | |
| Rural | 59 (0.7) | 28 (1.1) |
| Suburban | 60 (0.7) | 27 (0.8) |
| Urban | 62 (0.7) | 27 (1.3) |

1 The differences between classes composed of mostly high prior achievers and those composed of mostly low prior achievers are significant for both composites (two-tailed z-test; $p < 0.05$).
2 The difference between the highest quartile and lowest quartile of percent of students in school eligible for FRL is significant for the Use of Reform-Oriented Teaching Practices composite (two-tailed z-test; $p < 0.05$).
3 The difference between the largest schools and the smallest schools is significant for the Use of Instructional Technology composite (two-tailed z-test; $p < 0.05$).

In addition to reform efforts in science education, the current policy environment emphasizes student assessment in science. The survey asked how often students in the randomly selected class were required to take assessments the teacher did not develop, such as state or district benchmark assessments. At the elementary level, 50 percent of classes never take external science assessments; the large majority of secondary classes take external assessments at least once per year (see Table 22).

**Table 22**
**Frequency of Required External Testing in Classes, by Grade Range**

| | Percent of Classes | | |
|---|---|---|---|
| | **Elementary** | **Middle** | **High** |
| Never | 50 (2.3) | 21 (1.6) | 30 (1.5) |
| Once a year | 17 (1.6) | 28 (2.2) | 35 (1.6) |
| Twice a year | 8 (1.2) | 13 (1.8) | 13 (1.0) |
| Three or four times a year | 16 (1.6) | 23 (2.0) | 14 (1.1) |
| Five or more times a year | 9 (1.6) | 15 (1.4) | 9 (0.9) |

However, as can be seen in Table 23, students more likely to be required to take external science assessments twice or more per year are those in science classes:

- Composed of mostly low achieving students,
- Composed of the highest percentages of students historically underrepresented in STEM,
- In schools composed of the highest percentages of students eligible for FRL, and
- In the largest schools.

**Table 23**
**Science Classes Required to Take External Assessments Two or More Times per Year, by Equity Factors**

| | Percent of Classes | |
|---|---|---|
| **Prior Achievement Level of Class[1]** | | |
| Mostly High Achievers | 36 | (3.1) |
| Average/Mixed Achievers | 36 | (1.7) |
| Mostly Low Achievers | 53 | (3.6) |
| **Percent of Historically Underrepresented Students in Class[2]** | | |
| Lowest Quartile | 26 | (2.4) |
| Second Quartile | 30 | (2.6) |
| Third Quartile | 38 | (3.3) |
| Highest Quartile | 52 | (2.4) |
| **Percent of Students in School Eligible for FRL[3]** | | |
| Lowest Quartile | 33 | (2.9) |
| Second Quartile | 35 | (2.4) |
| Third Quartile | 45 | (3.5) |
| Highest Quartile | 50 | (3.0) |
| **School Size[4]** | | |
| Smallest Schools | 30 | (3.0) |
| Second Group | 36 | (3.0) |
| Third Group | 39 | (3.3) |
| Largest Schools | 47 | (2.6) |
| **Community Type** | | |
| Rural | 34 | (2.6) |
| Suburban | 39 | (2.0) |
| Urban | 40 | (2.9) |

[1] The difference between classes composed of mostly high prior achievers and those composed of mostly low prior achievers is significant (two-tailed z-test; $p < 0.05$).
[2] The difference between the highest quartile and lowest quartile of percent of historically underrepresented students in class is significant (two-tailed z-test; $p < 0.05$).
[3] The difference between the highest quartile and lowest quartile of percent of students in school eligible for FRL is significant (two-tailed z-test; $p < 0.05$).
[4] The difference between the largest schools and the smallest schools is significant (two-tailed z-test; $p < 0.05$).

School environments can also have profound effects on students' science instruction experiences. School program representatives were asked about a number of issues that might affect science instruction. Five composites were created from these items. These composites are:

**Supportive context for science instruction**

1. District science professional development policies and practices
2. Time provided for teacher professional development in science
3. Importance that the school places on science
4. Public attitudes toward science instruction
5. Conflict between efforts to improve science instruction and other school and/or district initiatives
6. How science instructional resources are managed (e.g., distributing and refurbishing materials)

**Extent to which lack of materials and supplies is problematic**

1. Lack of science facilities (e.g., lab tables, electric outlets, faucets and sinks in classrooms)

2. Inadequate funds for purchasing science equipment and supplies
3. Inadequate supply of science textbooks/modules
4. Inadequate materials for individualizing science instruction

**Extent to which student issues are problematic**
1. Low student interest in science
2. Low student reading abilities
3. Large class sizes
4. High student absenteeism
5. Inappropriate student behavior

**Extent to which a lack of time for science is problematic**
1. Insufficient time to teach science
2. Lack of opportunities for science teachers to share ideas
3. Inadequate science-related professional development opportunities

**Extent to which teacher issues are problematic**
1. Lack of teacher interest in science
2. Inadequate teacher preparation to teach science

As can be seen in Table 24, there are similarities and differences by the equity factors in regard to the extent that school environments impact science instruction. Across composites, there are few variations by community type. Conversely, the largest schools are substantially more likely than the smallest schools to indicate that student issues, a lack of time for science, and teacher issues are problematic for science instruction. Similarly, schools with the highest percentages of students eligible for FRL are more likely than schools with the lowest percentages to indicate that student issues and teacher issues are problematic. Interestingly, schools appear to provide roughly equally supportive contexts for science instruction, regardless of school-level factors.

## Table 24
## School Mean Scores for Factors Affecting Science Instruction Composites, by Equity Factors

| | Mean Score | | | | |
|---|---|---|---|---|---|
| | Supportive Context for Science Instruction | Extent to Which a Lack of Materials and Supplies is Problematic | Extent to Which Student Issues are Problematic | Extent to Which a Lack of Time for Science is Problematic | Extent to Which Teacher Issues are Problematic |
| **Percent of Students in School Eligible for FRL[1]** | | | | | |
| Lowest Quartile | 65 (2.0) | 36 (3.8) | 17 (2.2) | 40 (2.4) | 16 (2.1) |
| Second Quartile | 56 (2.0) | 38 (2.8) | 29 (2.0) | 46 (2.6) | 26 (2.8) |
| Third Quartile | 61 (1.9) | 42 (2.3) | 35 (1.9) | 45 (2.4) | 23 (2.2) |
| Highest Quartile | 59 (2.5) | 42 (3.2) | 44 (2.2) | 45 (3.2) | 26 (2.8) |
| **School Size[2]** | | | | | |
| Smallest Schools | 64 (2.1) | 41 (2.4) | 26 (1.9) | 38 (2.4) | 14 (2.1) |
| Second Group | 56 (2.1) | 40 (2.4) | 32 (1.7) | 48 (2.7) | 27 (2.3) |
| Third Group | 64 (1.8) | 36 (2.4) | 32 (2.0) | 41 (2.1) | 24 (2.3) |
| Largest Schools | 62 (1.6) | 37 (2.1) | 34 (1.9) | 48 (2.4) | 29 (2.2) |
| **Community Type** | | | | | |
| Rural | 60 (1.9) | 40 (2.4) | 29 (1.9) | 40 (2.8) | 18 (2.4) |
| Suburban | 62 (1.4) | 37 (2.1) | 30 (1.6) | 44 (1.8) | 22 (1.7) |
| Urban | 63 (1.8) | 41 (2.8) | 31 (2.3) | 42 (2.2) | 23 (2.2) |

[1] The differences between the highest quartile and lowest quartile of percent of students in school eligible for FRL are significant for the Extent to Which Student Issues are Problematic and Extent to Which Teacher Issues are Problematic composites (two-tailed z-test; $p < 0.05$).

[2] The differences between the largest schools and the smallest schools are significant for the Extent to Which Student Issues are Problematic, Extent to Which a Lack of Time for Science is Problematic, and Extent to Which Teacher Issues are Problematic composites (two-tailed z-test; $p < 0.05$).

Teachers were also asked how the climate for science instruction affected instruction in their randomly selected class. Composites created from these items are:

**Extent to which the policy environment promotes effective instruction**

1. Current state standards
2. District curriculum frameworks
3. School/District pacing guides
4. State testing/accountability policies
5. District testing/accountability policies
6. Textbook/module selection policies
7. Teacher evaluation policies

**Extent to which stakeholders promote effective instruction**

1. Students’ motivation, interest, and effort in science
2. Students’ reading abilities
3. Community views on science instruction
4. Parent expectations and involvement

**Extent to which school support promotes effective instruction**

1. Time for you to plan, individually and with colleagues
2. Time available for your professional development

As with the program representative composites about supportiveness of context, there are no significant community type differences in the class composites (see Table 25). In contrast, classes composed of mostly high-achieving students are substantially more likely than those with low-achieving students to be in supportive environments. Classes in schools with the lowest percentages of FRL students and classes with the lowest percentages of historically underrepresented students have higher scores on the stakeholder support for effective science instruction composite than their respective highest-percentage counterparts. In contrast, there were no differences in mean scores on the stakeholder support of effective science instruction composite by school size. Finally, classes in the largest schools are more likely than those in the smallest schools to have supportive school environments for effective science instruction.

**Table 25**
**Class Mean Scores on Factors Affecting Science Instruction Composites, by Equity Factors**

| | Mean Score | | |
|---|---|---|---|
| | **Extent to Which the Policy Environment Promotes Effective Instruction** | **Extent to Which Stakeholders Promote Effective Instruction** | **Extent to Which School Support Promotes Effective Instruction** |
| **Prior Achievement Level of Class**[1] | | | |
| Mostly High Achievers | 67 (2.3) | 76 (1.6) | 70 (2.1) |
| Average/Mixed Achievers | 64 (0.7) | 66 (0.9) | 64 (1.2) |
| Mostly Low Achievers | 59 (2.6) | 51 (2.0) | 57 (4.0) |
| **Percent of Historically Underrepresented Students in Class**[2] | | | |
| Lowest Quartile | 61 (2.2) | 68 (1.7) | 63 (2.3) |
| Second Quartile | 65 (1.3) | 70 (1.4) | 65 (2.7) |
| Third Quartile | 64 (1.7) | 66 (1.6) | 63 (2.0) |
| Highest Quartile | 65 (1.3) | 60 (1.3) | 64 (1.9) |
| **Percent of Students in School Eligible for FRL**[3] | | | |
| Lowest Quartile | 66 (1.7) | 75 (1.6) | 67 (2.1) |
| Second Quartile | 62 (1.8) | 66 (1.5) | 61 (2.3) |
| Third Quartile | 64 (2.3) | 61 (1.5) | 64 (2.6) |
| Highest Quartile | 63 (1.4) | 58 (1.5) | 63 (2.2) |
| **School Size**[4] | | | |
| Smallest Schools | 64 (1.8) | 66 (1.8) | 59 (2.3) |
| Second Group | 63 (1.5) | 66 (1.5) | 65 (1.9) |
| Third Group | 66 (1.4) | 66 (1.5) | 65 (2.9) |
| Largest Schools | 62 (1.3) | 66 (1.4) | 66 (2.0) |
| **Community Type** | | | |
| Rural | 64 (1.8) | 64 (1.6) | 61 (2.1) |
| Suburban | 64 (0.8) | 65 (1.0) | 65 (1.4) |
| Urban | 65 (1.8) | 69 (1.2) | 65 (2.6) |

1 The differences between classes composed of mostly high prior achievers and those composed of mostly low prior achievers are significant for all three composites (two-tailed z-test; $p < 0.05$).

2 The difference between the highest quartile and lowest quartile of percent of historically underrepresented students in class is significant for the Extent to Which Stakeholders Promote Effective Instruction composite (two-tailed z-test; $p < 0.05$).

3 The difference between the highest quartile and lowest quartile of percent of students in school eligible for FRL is significant for the Extent to Which Stakeholders Promote Effective Instruction composite (two-tailed z-test; $p < 0.05$).

4 The difference between the largest schools and the smallest schools is significant for the Extent to Which School Support Promotes Effective Instruction composite (two-tailed z-test; $p < 0.05$).

# DISCUSSION

The goal of the 2012 NSSME was to take a panoramic snapshot of K–12 science and mathematics; it was not designed primarily as an equity study. However, given the comprehensive set of data, it is possible to apply several equity lenses during analysis. This paper explored five such lenses:

- Prior achievement level of students in the class;
- Percentage students historically underrepresented in STEM in the class;
- Percentage of students in the school eligible for FRL;

- School size; and
- Location of the school (rural, suburban, urban).

The purpose of this paper was to highlight some of the affordances and limitations of the data available through the 2012 NSSME. We also chose to look at equity as a resource-allocation problem, exploring how three resources—teachers, material resources, and instruction—are allocated among classes and schools. The approach of inspecting resources through various equity lenses is just one of many that could have been taken.

As noted in the introduction, some of the "equity factors" we examined are correlated. For example, schools with a high percentage of students eligible for FRL also tend to have classes with high percentages of students historically underrepresented in STEM. This artifact of the analytical approach has both pros and cons. On the one hand, researchers may choose a lens that is best aligned with their theoretical framework. On the other, they may use a particular lens just because it happens to show an inequity (or not).

In addition, the FRL lens may lead to a somewhat distorted picture. Although some inequities are apparent when the data are viewed through this lens, they tend to be between schools with the highest and lowest percentages of FRL students. In between these extremes, there is often not a clear pattern. We suspect that Title 1 funding explains this finding; i.e., when the percentage of students eligible for FRL reaches a certain point, schools actually receive more resources. A more sophisticated approach to FRL than parsing schools into quartiles may be needed.

Historically, the prior achievement level of students in a class has not been used as a lens to explore the allocation of resources. However, this way of looking at the data points to numerous inequities, and in each one low-achieving students lose out. Not only do these students come to class with weaker backgrounds (as perceived by their teachers), they tend to be placed in classes with students of similarly weak backgrounds, with fewer resources than classes with mostly high-achieving students. This pattern holds true whether the resource is teachers (e.g., classes of low-achieving students are more likely to have inexperienced teachers), equipment (e.g., classes of low-achieving students are much less likely to have access to microscopes), or instruction (e.g., classes of low-achieving students are much more likely to spend class time taking external assessments). Arguments against ability grouping abound in the literature, and data from the 2012 NSSME support the assertion that ability grouping is associated with inequities in resource allocation.

Each of the equity lenses has affordances and limitations. Two of them—prior achievement and FRL—are associated with differences in many of the outcomes examined. The Appendix lists the outcome variables discussed in this paper and indicates whether an inequity was evident when viewed through each lens.

The 2012 NSSME provides equity researchers with a robust data set for exploring student opportunities to learn science. This paper presents one way of thinking about the data—resource allocation viewed through the various equity lenses. We invite the field to explore other approaches.

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# Appendix

## Differences in Outcome Variables, by Equity Lenses

| | Equity Lenses | | | | |
|---|---|---|---|---|---|
| | Class-level | | School-level | | |
| | Prior Ach. level | Hist. Under. in STEM | FRL | School Size | Comm. Type |
| **Well Prepared Teachers** | | | | | |
| Science classes taught by teachers with 0–5 years of science teaching experience | ✓ | ✓ | ✓ | | |
| Secondary teachers with a degree in science or science education | NA | NA | ✓ | | |
| Teachers' perceived preparedness to teach students from diverse backgrounds | ✓ | | ✓ | | |
| Teachers' perceived preparedness to encourage students' interest in science | ✓ | ✓ | ✓ | | |
| Teachers' perceived preparedness to teach science content (not self-contained classes) | ✓ | | | ✓ | |
| Teachers' perceived preparedness to implement instruction in a particular unit | ✓ | ✓ | ✓ | | |
| Classes taught by science teachers with >35 hours PD in last 3 years | ✓ | | | | ✓ |
| Quality of PD composite mean score | ✓ | ✓ | | ✓ | |
| Schools providing science-focused study groups | NA | NA | | ✓ | |
| Schools providing one-on-one science-focused coaching | NA | NA | ✓ | ✓ | ✓ |
| Schools providing assistance to science teachers in need | NA | NA | | | |
| **Material Resources** | | | | | |
| Adequacy of resources for science instruction composite mean score | ✓ | ✓ | ✓ | | |
| Availability of graphing calculators | ✓ | | | | |
| Availability of non-graphing calculators | ✓ | ✓ | | ✓ | ✓ |
| Availability of probes for data collection | ✓ | | | | |
| Availability of microscopes | ✓ | | ✓ | | |
| Extent to which IT quality is problematic for science instruction composite mean score | ✓ | ✓ | | | |
| **Measures of Science Instruction** | | | | | |
| Minutes per day of science instruction | | | | | |
| Number of AP course offerings | NA | NA | ✓ | ✓ | ✓ |
| Reform-oriented instructional objectives composite mean score | ✓ | | ✓ | | |
| Use of reform-oriented teaching practices composite mean score | ✓ | | ✓ | | |
| Use of instructional technology composite mean score | ✓ | | | ✓ | |
| External assessments twice or more per year | ✓ | ✓ | ✓ | ✓ | |
| Supportive context for science instruction composite mean score | NA | NA | | | |
| Student issues problematic composite mean score | NA | NA | ✓ | ✓ | |
| Teacher issues problematic composite mean score | NA | NA | ✓ | ✓ | |
| Policy environment promotes effective science instruction composite mean score | ✓ | | | | |
| Stakeholders promote effective science instruction composite mean score | ✓ | ✓ | ✓ | | |
| School support promotes effective science instruction composite mean score | ✓ | | | ✓ | |

† Note: Check marks indicate presence of significant differences between factor subgroups (e.g., between highest and lowest quartile mean scores). NA indicates that a particular equity lens could not be applied to the outcome variable.