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Changing the Subject

K–12 Teachers' Use of and Access to Science-Specific Instructional Materials, Feedback, and Professional Learning

Key Findings

- Teachers are more likely to rely on self-created and non-curriculum materials in science than in math or English language arts (ELA).
- Teachers are less likely to report that principals provide feedback on science curricula and know which science curricula are standards-aligned.
- Teachers engage in science-specific professional development significantly less than ELA- and math-specific professional development.

Abbreviations

AEP	American Educator Panels
AIRS	American Instructional Resources Survey
EL	English learner
ELA	English language arts
FRPL	free or reduced-price lunch
NAEP	National Assessment of Educational Progress
NGSS	Next Generation Science Standards
NSTC	National Science and Technology Council
STEM	science, technology, engineering, and mathematics

Introduction

In a 2018 report, the National Science and Technology Council (NSTC) identified K–12 schooling as an "essential prerequisite" for supporting the U.S. federal government's aims in furthering science, technology, engineering, and mathematics (STEM) learning and careers (Committee on STEM Education of the National Science and Technology Council, 2018, p. v). However, the work and needs of K–12 science instructors often have been lost amid broader K–12 education reform movements (Au, 2007; Lowenhaupt and McNeill, 2019). Although state and federal policymakers have directed great attention toward the inputs and outputs of math and English language arts (ELA) instruction, the same attention has not been paid toward science instruction. As of 2018, only 24 states included science achievement in their school accountability systems, with other policies for testing, accountability, instructional time, and student course-taking in science often left to local discretion (Achieve, 2019).

The most recent National Assessment of Educational Progress (NAEP) assessments available in each subject suggest that students perform comparably in science as they do in math and ELA. However, science proficiency rates remain low overall, with fewer than 40 percent of 4th, 8th,

or 12th grade students scoring at or above NAEP proficient in the most recent NAEP science assessment, which was conducted in 2015 (National Center for Education Statistics, 2016). Additionally, several studies using the nationally representative Early Childhood Longitudinal Program, Kindergarten Class survey found that racial and ethnic achievement gaps in science are typically larger than gaps among those same subgroups in reading or math (Curran and Kellogg, 2016; Curran and Kitchin, 2019; Quinn and Cooc, 2015). Low and inequitable levels of science performance nationally threaten to hamper the ambitious goals for STEM careers set by the NSTC and other organizations.

K–12 classroom instruction is not the product of any single input. Instead, it emerges from a "coherent instructional system" in which educators are supported by instructional materials, evaluation and feedback from school leaders, and professional learning opportunities, among other factors (Kaufman et al., 2020, p. 2). In this Data Note, we use nationally representative survey data of K–12 teachers from the 2020 American Instructional Resources Survey (AIRS) to examine how teachers' science instruction is supported by some of these factors and whether these supports differ from what teachers report for ELA and math instruction. Specifically, we use data from the 2020 AIRS to examine the following research questions:

1. To what extent do teachers report using self-created or non-curriculum materials as part of their main instructional materials in science?
2. To what extent do principals understand science standards, provide feedback on the use of science curricula, and incorporate science curricula into observation processes?
3. To what extent do teachers report participating in science-specific professional development?
4. Do teacher reports of instructional material use, evaluation and feedback, and professional development differ between science and ELA and math?

Broadly, we found marked differences in teachers' reports of these factors as they relate to the science instructional environment relative to teachers' reports on instructional environments in ELA and math. These differences suggest that access to formal

Sample: Defining *Science Instructors*

Using the 2020 AIRS, researchers asked roughly 6,000 K–12 teachers both general and subject-specific (ELA, math, science) items concerning their use of instructional materials; perceptions and modifications of those materials; and other school supports, such as professional development, evaluation, and feedback, for those materials. To limit survey burden, teachers indicating that they teach multiple subjects were randomly assigned to answer subject-specific items for only one subject. Although this Data Note focuses on the responses of 1,484 teachers to science-specific survey items, only 45 percent of these teachers reported exclusively teaching science. Naturally, the majority (90 percent) of teachers who reported teaching science along with other subjects were elementary school teachers in self-contained classrooms. Therefore, we describe materials, feedback, and professional learning by subject (e.g., "teachers' access to science-specific professional learning") rather than describe teachers themselves (e.g., "science teachers' access to professional learning") to acknowledge the possibility of multisubject teachers in the sample.

materials, feedback, and support is lacking for science instruction relative to instruction in ELA and math. We discuss our data and findings in further detail and conclude with implications and policy recommendations that are based on the analysis presented in this Data Note.

Teachers Are *More Likely* to Rely on Self-Created and Non-Curriculum Materials in Science Than in Math or ELA

One of the primary uses of the AIRS data is to examine trends and patterns in teachers' use of instructional materials, with one key feature of instructional materials being whether they are aligned with standards (e.g., Kaufman et al., 2020; Wang et al., 2021). However, because efforts to rate the standards alignment of science curricula are still nascent, cross-subject comparisons of standards alignment inclusive of science curricula are not possible. This limitation is more than a technical missing data problem and points to the need for expanding ratings of science curricula to inform practitioners and researchers who are interested in such cross-subject comparisons as those conducted in this Data Note.

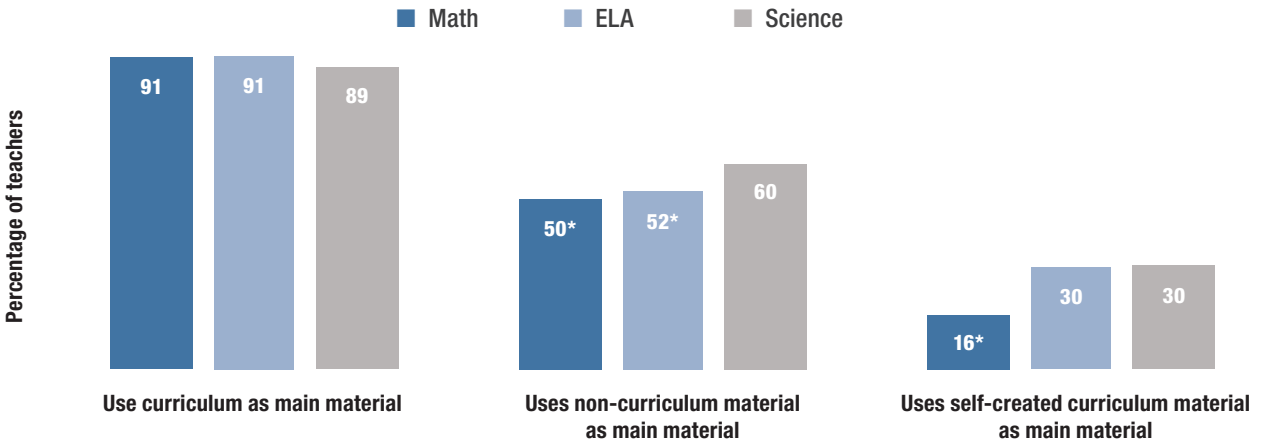
However, there are other dimensions of the materials teachers used that are comparable across subjects. The AIRS asks teachers to indicate all the specific materials they use across three categories of instructional materials: (1) comprehensive curricula that constitute a complete course of study, (2) additional materials that are used in classroom instruction that are not comprehensive curricula (e.g., Khan Academy), and (3) additional materials that are used to plan classroom instruction that are not comprehensive curricula (e.g., Teachers Pay Teachers). For all categories, teachers also have the option to indicate that they use self-created materials. Across all categories, teachers are asked to select the one to three materials that they consider to be their main material(s).

We focus on the types of materials that teachers consider to be their main materials, as selected by teachers in the AIRS, and report in Figure 1

FIGURE 1

Teachers Are More Likely to Report Using Self-Created and Non-Curriculum Materials for Science Instruction

Percentage of Teachers Using (1) Curriculum as Main Material, (2) Non-Curriculum Material as Main Material, and (3) Self-Created Curriculum as Main Material, by Subject



NOTES: This figure shows the percentage of teachers, by subject, who selected comprehensive curriculum material, non-comprehensive curriculum material, and self-created curriculum material as their main material. Teachers were allowed to select one to three main materials. * indicates math and ELA percentages that are significantly different from science percentages at the $p < 0.05$ level.

the percentage of teachers who selected (1) at least one comprehensive curriculum, (2) at least one non-comprehensive curriculum or additional material, and (3) a self-created curriculum as a main material across math, ELA, and science.

Nine of ten teachers indicated using at least one curriculum material as a main material, with no substantial differences by subject. However, we do find cross-subject differences with regard to the use of non-curriculum materials or self-created curriculum as main materials. Sixty percent of teachers classified a non-curriculum material as a main material in science, compared with 50 percent of teachers for math and 52 percent of teachers for ELA. When comparing the use of self-created curriculum, 30 percent of science teachers indicated that self-created curriculum materials were among their main materials, a comparable rate to that of ELA teachers (30 percent) but significantly higher than that of math teachers (16 percent).

As documented in Kaufman et al., 2020, teachers using a single published curriculum are the exception rather than the norm, with teachers commonly creating their own materials or combining multiple materials to form lessons. However, as shown in Figure 1, the use of self-created curriculum and non-curriculum materials is particularly high in the context of science instruction. Although the use of self-created or combined materials does not necessarily indicate that these lessons will be of lower quality, the need for teachers to seek out or develop their own science materials can impose considerable time burdens on these teachers and makes the task of coordinating science instruction more difficult for school, district, and state leadership.

Teachers Are *Less Likely* to Report That Principals Provide Feedback on Science Curricula and Know Which Science Curricula Are Standards-Aligned

Next, we considered how teachers reported on their school leaders' knowledge of subject-specific standards and the extent to which their evaluative feedback on the use of subject-specific curriculum differed among science, math, and ELA. Specifically, we examine the extent to which teachers agreed that "my principal provides me with feedback on how well I use science curricula," "my principal knows which curricula are and are not aligned with my state's standards," and "my teacher observations take into account my use of the required science curricula." Figure 2 shows the percentage of teachers who somewhat agree or strongly agree with each of these statements, disaggregated by subject.

Although the majority of teachers agreed with each of these items regardless of subject, the rate of agreement was significantly lower when teachers were asked about principal and evaluation supports specific to science than those same supports for ELA and math.

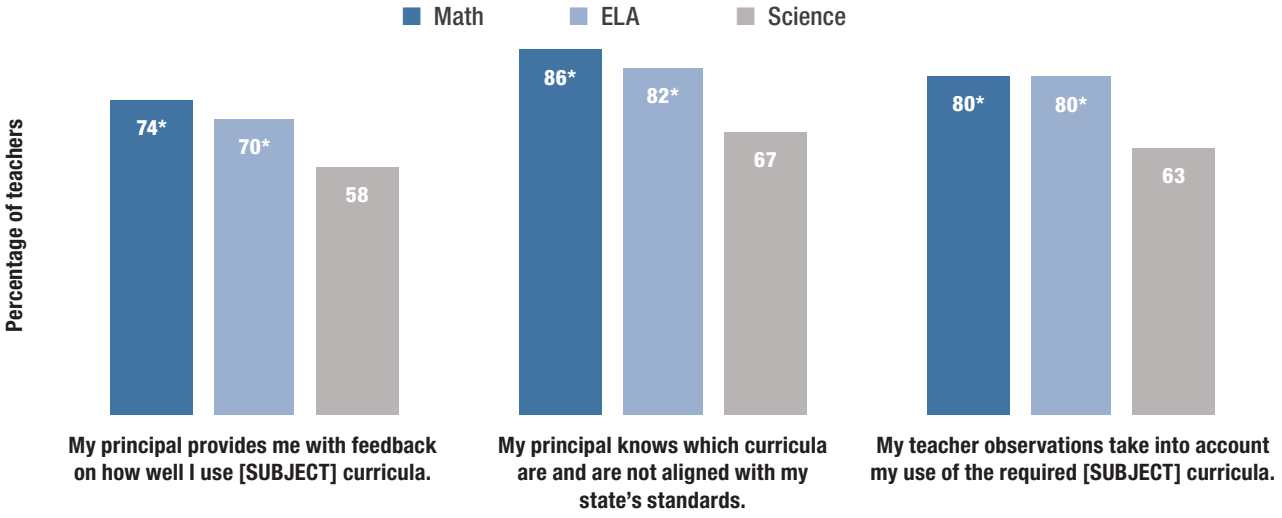
For example, while 74 percent and 70 percent of teachers agreed that their principal provided feedback on how well they use their math and ELA curricula, respectively, only 58 percent of teachers indicated the same with regard to science curricula. Likewise, the percentage of teachers agreeing that their principal understood which science curricula were aligned with state standards and that their observations took into account their use of science curricula was at least 15 percentage points lower than analogous items asking teachers to reflect on their math and ELA curricula.

There are several plausible reasons why teachers might report lower levels of school leader knowledge and feedback specific to science instruction. First, increased school leader emphasis on math and ELA instruction may be reflective of greater emphasis on achievement in these subjects in education

FIGURE 2

Teachers Are Less Likely to Agree That Principals Incorporate Use and Knowledge of Science Curricula and Standards into Feedback

Percentage of Teachers Agreeing with Statements on Principal Feedback and Knowledge of Subject-Specific Curricula and Standards



NOTES: This figure shows the percentage of teachers, by subject, who indicated that they somewhat agree or strongly agree that (1) "My principal provides me with feedback on how well I use [SUBJECT] curricula," (2) "My principal knows which curricula are and are not aligned with my state's standards," and (3) "My teacher observations take into account my use of the required [SUBJECT] curricula." * indicates math and ELA percentages that are significantly different from science percentages at the $p < 0.05$ level.

accountability systems. Science achievement goals are optional for states under the Every Student Succeeds Act, and efforts to adopt and promote national science standards, such as the Next Generation Science Standards (NGSS), have lagged behind standards reform in math and ELA (Achieve, 2019). Second, school leaders themselves may have less science-specific training and experience that would enable them to offer science-specific feedback to teachers (Lowenhaupt and McNeill, 2019). Using data from the 2020 AIRS administered to school leaders, we find that a slightly smaller percentage of school leaders report having postsecondary degrees in biology or natural sciences (7 percent) than English language and literature (8 percent) or mathematics (11 percent), although these differences are not statistically significant.

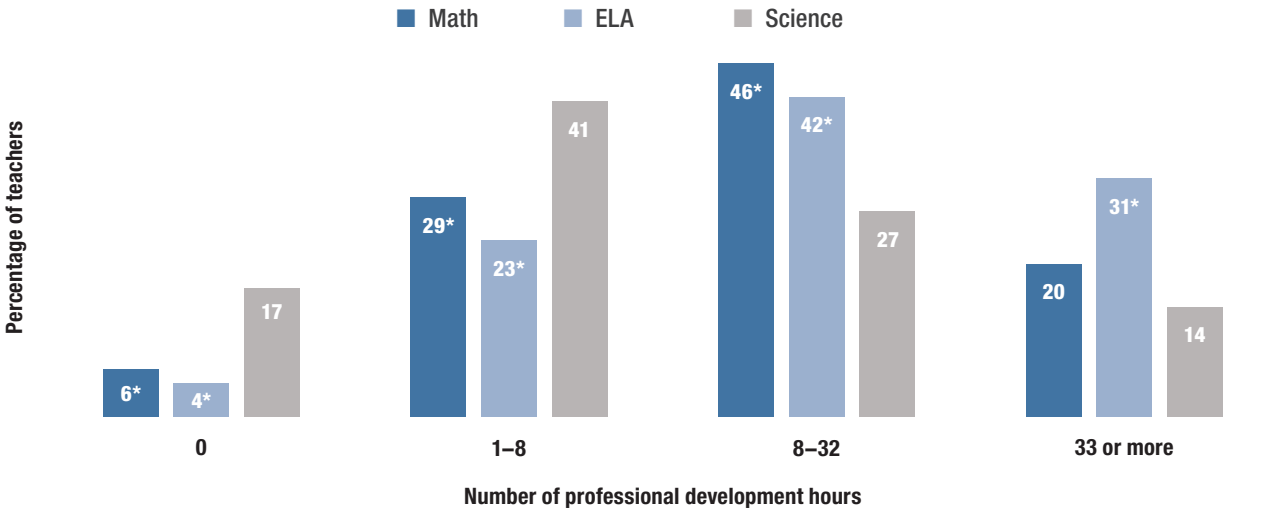
Teachers Engage in Science-Specific Professional Development *Significantly Less* Than ELA- and Math-Specific Professional Development

Finally, we explored differences in subject-specific professional development engagement among teachers. In Figure 3, we present the total number of subject-specific professional development hours teachers reported participating in during the 2019–2020 school year, separated by subject. Overall, we find that teachers were significantly more likely to report participating in either zero or one to eight hours of total science professional development than they were to report the same amount of math or ELA professional development. Specifically, 17 percent of teachers reported participating in zero hours of science professional development since the last academic year, compared with only 6 percent

FIGURE 3

Teachers Participate in More Hours of Professional Development in ELA and Math Than in Science

Percentage of Teachers Participating in Professional Development by Subject Since the End of the 2018–2019 School Year



NOTE: This figure shows the percentage of teachers, by subject, who responded to the following question: "Since the end of last school year (2018–19), can you estimate roughly how many hours of professional development you received altogether that were focused on your [SUBJECT AREA] teaching?" Response categories are zero hours, less than eight hours, eight to 16 hours (i.e., one to two days), 17–32 hours (i.e., three to four days), 33–48 hours (i.e., five to six days), 49–64 hours (i.e., seven to eight days), and more than 64 hours (i.e., more than eight days). * indicates math and ELA percentages that are significantly different from science percentages at the $p < 0.05$ level.

and 4 percent of teachers reporting on their math and ELA professional development, respectively. Similarly, 41 percent of teachers reported participating in only one to eight hours of professional development, at least ten percentage points higher than teachers in other subject areas. In comparison, majorities of teachers, 73 percent and 66 percent, reported spending more than one day (eight or more hours) in subject-specific professional development in ELA and math, respectively.

Given these differences in overall subject-specific professional development, we took a deeper look into the distinct types of professional development in which teachers reported participating. Teachers were asked to indicate their participation in different types of subject-specific professional development (e.g., workshop or training, coaching, collaborative learning) in addition to two types of professional development (e.g., general workshops, online learning that teachers access on their own) that were not subject-specific. For each subject-specific type of professional development, teacher engagement with science-specific professional development was significantly lower than ELA or math-specific professional development, with teachers typically being 20 percentage points less likely to participate in each type of science-specific professional development.

We did not find that teachers who were asked to report on their science-specific professional development responded any differently on their participation in non–subject-specific types of professional development (general workshops, online learning teachers access on their own), which further supports our takeaway that the gap we observe is driven primarily by subject-specific forms of professional development.

Implications and Recommendations

Policymakers have made great strides to better coordinate science instruction across the country. The NGSS, which were developed by a consortium of states and associations and first released in 2013, have been adopted by 19 states and the District of Columbia, with another 21 states adopting science standards based on the NGSS. In response to this broader adoption of the NGSS, EdReports and similar organizations have ramped up the rating of science instructional materials, combining national efforts with local- and state-developed ratings of these materials (Achieve, 2019; EdReports, 2019).

However, because these efforts traditionally have been decoupled from reform movements for ELA and math instruction, the work of improving science instruction has not always moved in concert with reforms in other subjects. We find evidence of this decoupling when examining teachers' reports in the 2020 AIRS of how their use of instructional materials, evaluation and feedback, and access to professional development differed across subjects. Teachers' responses in regard to their science instruction often differed from their responses with regard to ELA and math. Based on our findings, we suggest different strategies that local, state, and federal policymakers could pursue to better align the quality of instruction across subjects:

- **Increase national and state efforts to produce and disseminate ratings of science instructional materials.** We find that teachers are more likely to incorporate self-created materials and non-curriculum materials into their science instruction than their math and ELA instruction. Although combining and creating instructional materials is common for all K–12 teachers (Kaufman et al., 2020; Wang et al., 2021), this curation process may be more difficult for science teachers given that efforts by EdReports and other organizations to provide comprehensive ratings of the quality of science instructional materials are ongoing (EdReports, 2019). Information highlighting the strengths and weaknesses of science instructional materials can help educators identify the materials that work best for their students.
- **Encourage educators with science degrees or science classroom experience to become school leaders with targeted recruitment and professional development.** Increased dissemination of information about the quality of science instructional materials and explicit guidance for school leaders to provide more subject-specific feedback can open the pathway for teachers to receive more science-specific feedback. However, these strategies may be limited in their effectiveness if there are not school leaders with the requisite science knowledge and experience to enact them. The use of targeted supports (e.g., selective recruiting, professional development) can develop districts' principal pipelines with educators with science backgrounds (Gates et al., 2020).
- **Increase science-specific professional learning modules and identify barriers that prevent science instructors from participating in professional learning.** We find that teachers were less likely to report participation in science-specific professional development opportunities relative to professional development in ELA and math. Further investigation may help determine whether this difference is a result of a lack of availability of science-specific professional learning or other factors that prohibit teachers from taking advantage of science-specific professional learning activities, such as increased instructional planning or instructional material search time commitments for science instructors.

Ambitious federal goals for preparing students for careers in STEM fields require coordinated efforts and supports for the country's science instructors. Increased attention to the need of science instructors, and the provision of supports to address those needs, are particularly important in light of documented shortages of STEM K–12 teachers across several states (e.g., Beck, 2020; Johnson, 2020; "WVU 'Gets

the Facts Out' to Help Reverse High School Math and Science Teacher Shortage in West Virginia, Nationwide," 2020). That said, the relative lack of guidance for science instruction we identify in this Data Note does not necessarily indicate that the quality of science instruction is lower than the quality of instruction in ELA and math. However, it may foster an uneven environment for science instructors, making coordinated efforts to improve science instruction nationwide, such as those outlined by NSTC and NGSS, more difficult. To raise and equalize the level of science achievement in the United States, policymakers might first look toward raising the quality of and standardizing the materials and supports for science instruction that we outline in this Data Note.

Limitations

We intend for this Data Note to provide readers with an overview of how teachers' use of and access to science-specific instructional materials, feedback and evaluation, and professional learning differ compared with materials and supports provided in math and ELA. Although these data are helpful for gathering a nationally representative look at teacher reports on these topics, they are limited in several important ways. First, given the nature of survey data, we rely on teacher self-reports, which may be prone to response bias, throughout this Data Note to quantify several topics of interest. Although self-report bias might affect the *absolute* magnitude of certain quantities of interest (e.g., the total hours of professional learning in which a teacher has engaged), we do not believe that this type of bias poses immediate threats to our inferences regarding the *relative* differences across subject areas because we do not believe that teachers are more likely to inflate responses when asked about science materials, feedback, and professional learning relative to other subjects. Second, in exploring subgroup differences across teachers' responses, it is important to emphasize the strictly descriptive nature of these patterns. Although we find that teachers' responses on several items differ across subject areas, these patterns are purely associational and should be explored more deeply in the context of other data to examine why these between-subject discrepancies exist.

How This Analysis Was Conducted

In this Data Note, we use responses from 5,978 teachers to the 2020 AIRS to examine teachers' use of main instructional materials, perceptions of support from principals, and subject-specific professional development participation. We also explored how these differ across classroom and school characteristics; sample sizes for figures are smaller because of nonresponse to specific items.

On the 2020 AIRS, teachers were asked to select one to three instructional materials that they considered to be their main instructional materials—those that teachers indicated using "the most." Non-curriculum materials were classified as teachers' selection of an "additional material" (e.g., YouTube, BetterLesson, Teachers Pay Teachers). The additional materials were listed separately from curriculum materials; *curriculum materials* were defined to respondents as instructional materials that were intended to constitute a full, comprehensive course of study for a particular subject and grade level.

For the perceptions of support from principals items, respondents were asked to indicate their level of agreement with statements relating to how their principals support their curriculum use and instruction. Each item had the following response options: "strongly disagree," "somewhat disagree," "somewhat agree," "strongly agree," and "N/A."

In the professional development section, respondents were asked how often they participated in different types of subject-specific professional learning activities. They were given the following response options: "never," "1–3 times per year," "4–6 times per year," "1–3 times per month," and "weekly or more often." These options were then grouped into two categories: any participation (for respondents who chose any response other than "never") and once per month (for respondents who chose responses "1–3 times per month" or "weekly or more often"). The differences across subject-specific responses represent a consistent difference in both categories.

We compared teachers' responses on the subject-specific professional development participation questions across different school characteristics, including school enrollment of students eligible for free and reduced-price lunch (FRPL), school enrollment of non-white students, and school urbanicity (city, suburban, town, rural), as well as the subject (ELA, mathematics, science) and classroom-level percentage of English learner (EL) students taught by that teacher. School characteristics were obtained from the 2018–2019 National Center for Education Statistics Common Core of Data, and the teacher-reported classroom-level percentage of EL students was obtained from teacher responses to the 2020 AIRS. School characteristics were operationalized as quartiles. Teachers were asked to estimate the percentage of EL students in their classroom within one of the following categories: (1) 10 percent or less, (2) 11 to 24 percent, (3) 25 to 49 percent, (4) 50 to 74 percent, and (5) 75 to 100 percent. We conducted *t*-tests to test for significant pairwise differences among quartiles or categories on each school or classroom characteristic.

All comparisons mentioned in this Data Note are unadjusted for statistical controls and are significant at the $p < 0.05$ level unless otherwise specified. We tested the robustness of these patterns using the inclusion of school characteristics (e.g., urbanicity, FRPL eligibility rate, racial composition) and teachers' grade taught and years of total teaching experience. Because these results are substantively similar, we present only unadjusted descriptive results in this Data Note.

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Key Recommendations in This Report

Increase national and state efforts to produce and disseminate ratings of science instructional materials.

Encourage educators with science degrees or science classroom experience to become school leaders with targeted recruitment and professional development.

Increase science-specific professional learning modules and identify barriers preventing science instructors from participating in professional learning.

About This Report

The American Educator Panels (AEP) are nationally representative samples of teachers and school leaders across the country.

We are extremely grateful to the U.S. public school teachers and leaders who have agreed to participate in the panels. Their time and willingness to share their experiences are invaluable for this effort and for helping us understand more about how to better support their hard work in schools. We also thank our reviewers, Christine Mulhern and Peter Cormas, for helpful feedback that improved this report.

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About the AEP Data Note Series

The AEP Data Note series is intended to provide brief analyses of teacher and school leader survey results of immediate interest to policymakers, practitioners, and researchers. If you would like to know more about the dataset, please see the *American Instructional Resources Survey (AIRS) 2020 Technical Documentation and Survey Results* (RR-A134-4, www.rand.org/t/RRA134-4) for more information on survey recruitment, administration, and sample weighting. If you are interested in using AEP data for your own analysis or reading other AEP-related publications, please email aep@rand.org or visit www.rand.org/aep.

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