Science
Education

ISSUES AND TRENDS

Science Instructional Time Is Declining in Elementary Schools: What Are the Implications for Student Achievement and Closing the Gap?

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ABSTRACT: Recent comparative data on high school graduates show that many American students are not well prepared in fields of science, technology, engineering, and mathematics and that there is a persistent achievement gap according to the socioeconomic backgrounds of students. The research for this paper focuses on the role of elementary education in science as an important preparatory step. National trend data show a decline in instructional time in the elementary grades on science instruction over the past two decades. State-level data show wide variation in the amount of class time spent on science education and a positive relationship between the amount of class time and student achievement scores in science as measured by the National Assessment of Educational Progress Grade 4 assessment. © 2013 Wiley Periodicals, Inc. *Sci Ed* **97:**830–847, 2013

INTRODUCTION

American education policy makers have been strongly advised of the need for more graduates in the fields of science, technology, engineering, and mathematics (STEM) (President's Council of Advisers on Science and Technology, 2012; Thomasian, 2011).

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However, data on the performance of American students show that many students are not well prepared in STEM fields at high school graduation (Nord et al., 2011), and that there is a persistent achievement gap according to the socioeconomic backgrounds of students (Barton & Coley, 2010; Darling-Hammond, 2010; Obed, Ault, Bentz, & Meskimen, 2001; Provosnik, Gonzales, & Miller, 2009; U.S. Department of Education, National Center for Education Statistics, 2011a). This paper focuses on the role of elementary education in science as an important preparatory step. Using national- and state-level data, the paper describes analyses of classroom instructional time in science in U.S. elementary schools and the relationship of class time to student achievement and closing the achievement gap.

EXAMINING QUESTIONS ON INSTRUCTIONAL TIME AND ELEMENTARY SCIENCE

Existing research evidence shows that early education in science and mathematics is important as preparation for students pursuing study and careers in STEM fields (Gettinger, 1985; Harris Interactive, 2011; Karweit, 1983; Osborne, 2003; Traphagen, 2011). Although states set high school graduation requirements and course credits by subject (Stillman & Blank, 2009), decisions about academic content taught in the elementary grades and the amount of time allocated to different subjects are often made at the local level and sometimes by individual teachers (Center on Education Policy, 2008; Murnane & Raizen, 1988). Thus the question of instructional time differences at the elementary level is an important research topic. This paper reports on data that directly address the question of time and attention to science teaching and learning in elementary schools. Class time for science instruction is a key indicator of opportunity to learn. The research aims to address three questions concerning elementary science instruction:

1. How much time is spent on science instruction in U.S. elementary school classrooms and has time devoted to science education in these grades changed over time?
2. Are differences in the amount of science instructional time at a specific grade (e.g., Grade 4) related to student achievement for that grade?
3. Is science instructional time in elementary classrooms related to demographics of the student population?

The main hypothesis being tested in the study is that instructional time in elementary science has a positive effect on student achievement. If the hypothesis is confirmed, the policy and program implications are important. Students who receive less instructional time in science in school are likely to have lower student achievement in science, and thus may have less chance of succeeding in subsequent study in science fields and in careers related to science education.

PRIOR RESEARCH ON INSTRUCTIONAL TIME AND STUDENT PERFORMANCE

Current U.S. education policy discussions are focused on how to advance the quality and effectiveness of science and mathematics education for all students. New reports from the National Research Council (NRC) (2011) and National Governors Association (NGA) (Thomasian, 2011) call attention to two key issues for American education systems for increasing the participation and preparation of more students in the STEM fields. First, there is a high demand for U.S. high school graduates who are prepared to enter careers requiring STEM knowledge (Kirsch Braun, Yamamoto, & Sum, 2007; President's Council of Advisers on Science and Technology, 2012). Carnevale, Smith, and Strohl (2010) report that by 2018, there will be more than 2.8 million job openings for STEM workers, and 92% of these jobs will require at least some postsecondary education. Second, results from the Trends in Mathematics Study and Program for International Student Assessment international studies indicate that average U.S. student performances on science and mathematics assessments do not compare favorably with results for students in leading industrialized nations (OECD, 2010; Provosnik, Gonzales, & Miller, 2009). U.S. federal policy focused on improving and increasing STEM education has remained high on the list of national priorities for education over a number of years (Carnegie Commission, 1991; National Academy of Science, 2007).

One policy strategy for improving STEM education and production is to ensure that elementary schools are providing appropriate early learning and support needed for later study in the STEM fields (Loucks-Horsley et al., 1991; Mullis & Jenkins, 1988; Duschl, Schweingruber, & Shouse, 2007). Researchers on time and learning have found that class time needs to be allocated regularly during the school day and week and that instructional time is a key equity issue (Gettinger, 1985; Karweit, 1983; National Center on Time and Learning, 2010; Traphagen, 2011). Class time in school is a key equity issue because opportunity to learn science concepts and knowledge varies by the family backgrounds of students (Barton & Coley, 2008; Braun, Coley, Jia, & Trapani, 2009; Darling-Hammond, 2010; Darling-Hammond, 2004; Obed, Ault, Bentz, & Meskimen, 2001). Students from higher levels of socioeconomic backgrounds have more opportunities for reading and studying at home (Barton & Coley, 2010; Oakes, 1990; U.S. Department of Education, National Center for Education Statistics, 2011a). Opportunity to learn science and mathematics is the result of what is taught in school as well as the influence of the home environment and informal learning experiences such as through museums (McKnight et al., 1987; Porter & Smithson, 2001; Schmidt, McKnight, Cogan, Jakwerth, & Houang, 1999). Time devoted to core academic subjects was a primary focus of the reform recommendations of the National Commission on Excellence in Education report, *A Nation at Risk* (1983). In the ensuing years, almost all states increased core academic subject requirements continuing to the present, with a particular focus on mathematics and science education (Stillman & Blank, 2009).

The recommendations for improvement of science education from the NRC indicate that the elementary years are an important time to capture students' interest and motivation for science study and that time for science instruction is critical (NRC, 2007, 2012). A review of some 150 studies of children's attitudes toward science found that interest in science for some children tends to decline from age 11 onward (Osborne, 2003), and thus elementary grades instruction in science provides a key time for building interest. Results from a recent survey of college students showed that nearly four in five STEM majors (78%) said they decided to study STEM in high school or earlier—and one in five (21%) said they made their decisions in middle school or earlier (Harris Interactive, 2011). Study of science in the elementary curriculum provides students with an important opportunity and context for applying skills developed in language arts and mathematics, as well as to appreciate the enjoyment of learning related to real-world questions and issues (NRC, 1996, 2007). Reduced time for science in the elementary curriculum would impact opportunity to learn for all students.

Another policy strategy for improving the achievement of U.S. students is to change the use of statewide student assessments to reinforce the importance of science education. Decisions about curriculum and instruction are affected by federal and state policies on assessment and accountability (Herman, 2004). For the past several years, the U.S. Congress has been debating reauthorization of the Elementary and Secondary Education Act (ESEA) and examining the effects of its 2001 reauthorization, the No Child Left Behind (NCLB)

Act. The NCLB law requires state testing and accountability reporting for reading and mathematics at each Grade 3–8 and one high school grade. Currently, science must be tested and reported publicly at three grades—at least one grade in elementary, middle, and high school levels. Student achievement scores in science are not required to be part of school annual progress determinations, although 12 states have chosen to include science scores as an additional accountability indicator (U.S. Department of Education, 2012). Recent research by Judson (2010, 2012) examined effects on student performance of states having a policy to include science in the accountability system. The NRC committee report recommends changes in the current law to include science assessment as part of the federal requirements for school accountability, with the goal to reinforce the role of science education in schools (2011, p. 21). The argument presented by the NRC committee is that science needs to be equally represented in assessment and accountability requirements in order for schools to adequately allocate instructional time to science. The National Science Teachers Association (NSTA) has, for a number of years, advocated for increased time in the school curriculum as a key ingredient to improve science education and student outcomes, especially in the elementary grades (NSTA, 2002; www.nsta.org).

The current federal requirement of annual reporting on adequate yearly progress in mathematics and reading for all students produces a strong incentive for schools to focus more instructional time on mathematics and reading, which can result in less class time for science, social studies, and other subjects. Thus, educators are concerned about the impact of public accountability requirements on science education across the nation. That is, how much time are teachers devoting to science instruction each week and has there been any substantial change over time? The data analyses presented in this paper examine trends over time, variation among states in time spent on science instruction, and the relationship of instructional time to student achievement. The goal of the research for this paper was to increase our understanding of the condition of science education in our schools. Careful data analysis and interpretation of results can help leaders and educators determine what is needed to improve student learning in science.

DATA SOURCES

The data sources for the analysis of science instruction at the elementary level are from national surveys of teachers conducted through the National Center for Education Statistics (NCES) of the U.S. Department of Education. The two sources are the Schools and Staffing Survey (SASS) and the National Assessment of Educational Progress (NAEP).

The first research question was analyzed with SASS data from surveys of elementary teachers in Grades 1–4. The survey data provide measures of time on instruction by subject, and the data for successive surveys using the same questions allow for analysis of change over time. The most recent available survey data are from the school year 2007–2008, when a representative sample of 800–1200 elementary and secondary public school teachers per state were surveyed in all 50 states (i.e., producing a nationally representative sample of 60,000 public school teachers). The same questions were asked from a sample of teachers every 4 years since the school year 1987–1988. The SASS data allow for reporting on the number of hours devoted to academic subjects per week, and comparison of time for science instruction with teaching in other elementary subjects. (Results were accessed from the NCES SASS Public School Teacher Survey, U.S. Department of Education, National Center for Education Statistics, 2011d.)

The second and third questions were analyzed with data from the NAEP 2009 Science Assessment at Grade 4. The NAEP results are based on data from assessments with a representative sample of students at Grade 4 in each participating state (46 states voluntarily participated) and from surveys with teachers of the Grade 4 students. The NAEP assessment is based on a sample of 2000 students per state for each assessed grade and subject. In addition to the student assessment, data collection included a survey of teachers of assessed students, a school-level science program survey, and a student survey (U.S. Department of Education, National Center for Education Statistics, 2011a). The survey responses provide a data source for analyzing several key characteristics of science instruction with results reported at the state and national level. Because the NAEP 2009 Science Assessment was developed with a new Science Assessment Framework, direct comparisons and analyses with prior NAEP Science Assessment results were not possible (National Assessment Governing Board, 2008). For this paper, state-level statistics based on aggregate NAEP 2009 data were used to analyze state-to-state variation on Questions 2 and 3. In addition, student- and teacher-level data from NAEP 2009 Science Assessment were analyzed using multivariate regression analysis of key variables in the study. The NAEP student assessment results and survey data were accessed through the NAEP Data Explorer (U.S. Department of Education, National Center for Education Statistics, 2011c).

ANALYSIS

Analysis of Question 1: Trends Analysis of Elementary Science Instructional Time (Grades 1–4) Using SASS Data

The average amount of time spent per week on science instruction and other core academic subjects is shown in Figure 1. The data were reported by elementary teachers of Grades 1–4 who are teaching in self-contained classes. The SASS results show that nationally, elementary teachers of Grades 1–4 in self-contained classrooms spent an average of 2.3 hours per week on science instruction during the school year 2007–2008. The

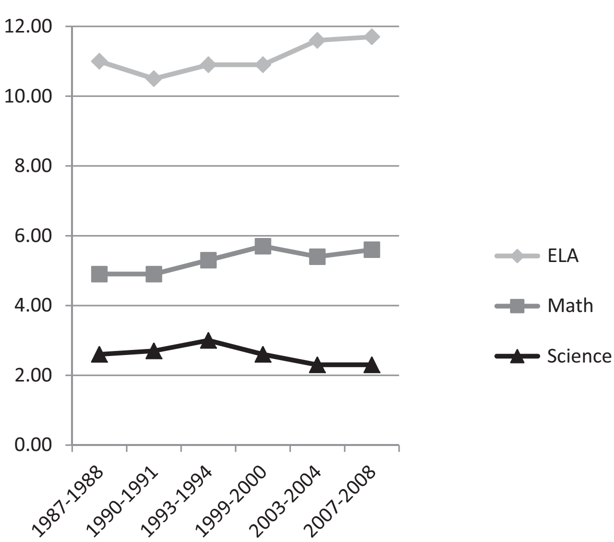

Figure 1. Trends in elementary instructional time by subject as reported by teachers in Grades 1–4: 1988–2008. Vertical axis = Hours of instruction per week; horizontal axis = year of survey. Reported data are from teachers in self-contained elementary classes, Grades 1–4. Statistical significance: Differences in average time on science instruction greater than 0.1 hours between the 4-year periods are statistically significant. Standard errors (SEs) for average hours by subject and year vary from 0.03 to 0.10. Differences that exceed the SE are significant at the $p < .05$ level. Source: U.S. Department of Education, National Center for Education Statistics, SASS, SASS Public School Teacher Survey. http://nces.ed.gov/surveys/sass/tables/sass0708_005_t1n.asp.

TABLE 1
Elementary Instructional Time by Subject from SASS Public Teacher Survey, Grades 1–4: 1988 to 2008

	Average Hours of Instruction per Week and Survey Year					
Subject	1987–1988	1990–1991	1993–1994	1999–2000	2003–2004	2007–2008
English	11.0	10.5	10.9	10.9	11.6	11.7
Mathematics	4.9	4.9	5.3	5.7	5.4	5.6
Social Studies	2.8	2.9	3.0	2.9	2.5	2.3
Science	2.6	2.7	3.0	2.6	2.3	2.3

Source: Surveys of teachers in self-contained classes Grades 1–4. U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Survey (SASS). "Public Teacher Data File," 1987–1988, 1990–1991, 1993–1994, 1999–2000, and 2003–2004, and 2007–2008. SEs for average hours by subject and year vary from 0.03 to 0.10. For all means and SE tables, go to http://nces.ed.gov/surveys/sass/tables/sass0708_005_t1n.asp.

instructional time for science can be compared to 11.7 hours per week on English language arts and reading in the average classroom, 5.6 hours spent on arithmetic/mathematics, and 2.3 hours per week on social studies. Figure 1 provides detail on the national trends for instructional time per week teachers reported their classes to have spent on core subjects over the past 20 years. *Time for science instruction in Grades 1–4 has declined from an average of 3.0 hours per week in 1993–1994 (180 minutes) to 2.6 hours (156 minutes) in 2000 and to 2.3 hours (138 minutes) in 2004 and 2008*. The trend line for science shows that less time is spent on science in elementary classrooms in 2008 than was spent on science in 1988, and less time was spent on science in 2008 than was spent on science in 2000.[1]

Table 1 shows the average hours of instructional time in Grades 1–4 on science and three other academic subjects and the pattern over time. The total time on the four subjects allows for a comparison of trends in the proportion of time spent on science instruction. The data show that although overall instructional time in elementary grades on the core subjects has increased over the past 20 years, the *percentage of the total time devoted to science instruction has declined.*[2] The total time allocated to four core subjects in 1987–1988 was 21.3 hours per week, whereas the total time in 2007–2008 was 21.9 hours per week.

At a time when proficiency in science is more important than ever, the average time students spend learning science in the elementary grades has declined. Through the late 1980s and 1990s, time spent on both science and mathematics was increasing. Since 1994, instructional time spent on mathematics has increased, time for reading and language arts has increased substantially, and time for science has dropped to an average of 2.3 hours (138 minutes per week or 28 minutes per day), which is the lowest level since national trends data began in 1988.

The national trends reported on a 4-year cycle from SASS are based on a representative stratified sample of elementary and secondary teachers (U.S. Department of Education, http://nces.ed.gov/surveys/sass/). Instructional time data are collected from elementary

[1]Differences in average time on science instruction greater than 0.1 hours between the 4-year periods are statistically significant. SEs for average hours by subject and year vary from 0.03 to 0.10. Differences that exceed the SE are significant at the $p < .05$ level. Source: U.S. Department of Education, National Center for Education Statistics, Schools and Staffing Survey (SASS). "Public Teacher Data File," 1987–1988, 1990–1991, 1993–1994, 1999–2000, and 2003–2004, and 2007–2008. For all means and SE tables, go to http://nces.ed.gov/surveys/sass/tables/sass0708_005_t1n.asp.

[2]The change in total time (0.6 hour) and percentage of time for science is significant. SEs for average hours by subject and year vary from 0.03 to 0.10 (see above).

teachers in self-contained classrooms in Grades 1–4, and the statistics are not available by individual grade. An advantage of the SASS results is that national trends are reported, and the results are comparable by 4-year intervals. (The 2008 data are the most recent 4-year cycle reported as of the present analysis.) SASS data do not include a measure of student achievement. Thus, the NAEP Science Assessment data were selected to provide an analysis of the second question regarding the relationship of instructional time and student achievement.

Analysis of Question 2: Analysis of Science Instructional Time and Student Achievement Using NAEP Data for Grade 4

The NAEP 2009 Science Assessment provides a measure of time on science instruction per week reported by Grade 4 teachers whose students took the NAEP assessments. In most elementary schools, the time spent on each academic subject is the product of several factors, including federal and state policies, state and local standards, district funding and priorities, school leadership, and teacher instructional decisions. The amount of instructional time per week is reported through the NAEP teacher survey, which is completed by teachers in each school selected into the NAEP sample for a specific subject and grade. The average instructional time is computed from responses from a representative state sample of 2000 students in each state at Grade 4. The analysis of science instructional time and the relationship to student achievement is conducted at the state aggregate level and at the student level.

The research study leading to the present paper focused on the 2009 fourth-grade NAEP assessment results in science and looked closely at the relationship of classroom instructional time and student background to student performance. In reviewing measures of educational factors in elementary science instruction reported by NAEP, such as types of instructional practices, curriculum emphasis, and teacher preparation, the class time on science instruction measure showed substantial differences across states and the potential for demonstrating a relationship to achievement. The recent recommendations for renewed focus on student preparation in the STEM fields and prior research on the relationship of early study to later student performance provided the motivation for this study of trends in instructional time, differences between states, and the relationship of time to student achievement.

In science and other subjects, there is wide variation in student NAEP scores at the national and the state level (Barton & Coley, 2008). NAEP Science Assessment average scale scores are reported by state in Table 2. The results show that students in the top performing states, such as New Hampshire, North Dakota, Virginia, and Kentucky, score on average above 160 on the NAEP scale, whereas the students in low-performing states such as Mississippi, California, and Arizona score on average below 140. Recent reports from state-level NAEP data analyses have focused largely on differences between states in the proportion of students meeting the NAEP proficiency level as compared to state-defined achievement levels (U.S. Department of Education, National Center for Education Statistics, 2011b) and analysis of state results in relation to international results (Hanushek, Woesmann, & Peterson, 2012). The research for this paper pursued the question of differences in performance on NAEP Science related to the time for science instruction reported by teachers of the fourth-grade students that were assessed.

The state aggregate measures reported in Table 2 show that among the 13 states with the highest average Grade 4 NAEP scores (New Hampshire, 163, to Wisconsin, 157), the average instructional time was more than 3 hours per week. Two states were in the top five states on both measures (Kentucky and Virginia). Thus, there is a pattern across states of more time on science classroom instruction in states with higher student NAEP scores. Considering the variability in the use of class instructional time, there are exceptions to the

TABLE 2
Science Instructional Time in Grade 4, NAEP Score, and Percent Low-Income Students, by State, NAEP Science 2009

State	Grade 4 Average Hours/Week	NAEP Scale Score	Low Income (%)
New Hampshire	2.6	163	22
North Dakota	3.2	162	33
Virginia	3.1	162	34
Kentucky	3.8	161	52
Maine	2.5	160	40
Massachusetts	2.4	160	34
Montana	2.6	160	41
DoDEA	3.2	159	Na
Minnesota	2.4	158	31
Iowa	2.9	157	37
Ohio	3.0	157	40
South Dakota	2.8	157	37
Wisconsin	3.0	157	39
Connecticut	2.4	156	30
Missouri	2.9	156	44
Wyoming	2.0	156	35
Colorado	2.7	155	37
New Jersey	3.0	155	33
Idaho	2.0	154	43
Pennsylvania	2.9	154	39
Utah	2.7	154	35
Delaware	3.1	153	43
Indiana	2.8	153	45
Florida	2.7	151	55
Oregon	1.9	151	46
Washington	2.3	151	45
Maryland	2.9	150	40
Michigan	3.2	150	43
Rhode Island	2.6	150	41
South Carolina	3.4	149	56
National public	2.8	149	48
Illinois	3.0	148	46
New York	2.6	148	52
North Carolina	2.6	148	48
Oklahoma	2.8	148	54
Tennessee	3.0	148	52
Texas	3.2	148	59
West Virginia	2.6	148	58
Arkansas	3.0	146	59
Georgia	3.1	144	56
Alabama	3.4	143	54
New Mexico	2.4	142	68
Louisiana	3.4	141	70
Nevada	2.2	141	41
Hawaii	2.1	140	45
Arizona	2.5	138	54

(Continued)

TABLE 2
Continued

State	Grade 4 Average Hours/Week	NAEP Scale Score	Low Income (%)
California	2.3	136	53
Mississippi	3.0	133	69

Note: Average hours/week = weighted average from teacher-reported number of hours. DoDEA = Department of Defense Education Activity. Statistical significance: NAEP scores *SE* vary from 1 to 3 points; a 4-point score difference is statistically significant at the $p < .01$ level. *SE* for science hours/week by state from 0.2 to 0.4 hour. Source: U.S. Department, of Education, NAEP 2009 Science Assessment. http://nces.ed.gov/nationsreportcard/naepdata/.

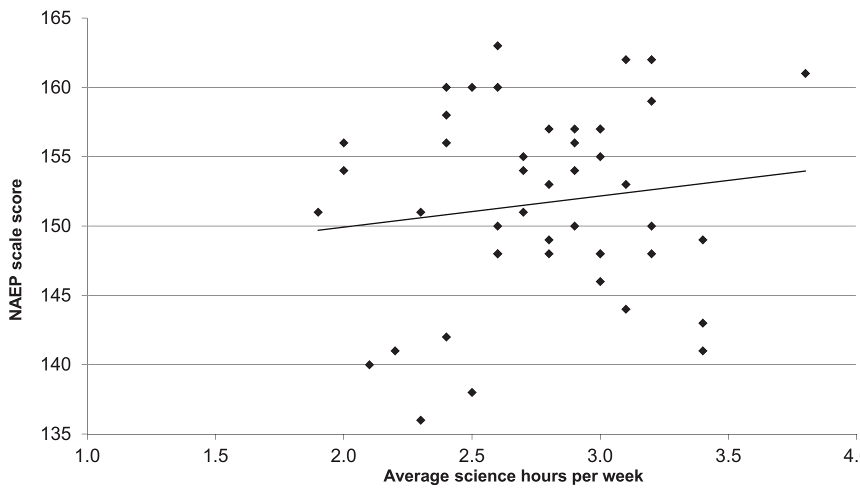

Figure 2. State NAEP Science score by average science instructional time, Grade 4, 2009. Statistical significance: NAEP scores *SE* vary by state from 1 to 3 points; a 4-point score difference is statistically significant. Source: U.S. Department of Education, NAEP 2009 Science Assessment. *SE* for science hours/week vary by state from 0.2 to 0.4 hour. http://nces.ed.gov/nationsreportcard/naepdata/.

pattern. Among the 13 highest scoring states, five states did have less than average time on science instruction in Grade 4.

A two-variable plot and line of the best-fit graph in Figure 2 shows the relationship between state average time on Grade 4 science instruction and the average NAEP Science achievement score for Grade 4 students.[3] The plot graph illustrates a positive relationship between these two variables—a state with 2.0 hours (120 minutes) per week of science instruction has an average NAEP score of 150; whereas a state with 3.5 hours per week (210 minutes) of science instruction has a NAEP average score of 154, and the difference of four points on the NAEP scale is statistically significant.[4] The plot of state average science instructional time by NAEP score shows four points in the upper

[3]On the NAEP Science Assessment, 10 scale points represent about 1 year of gain or difference in student achievement (based on comparing national Grade 4 and 8 scale scores). (U.S. Department of Education, National Center for Education Statistics, 2011c, 2009 NAEP Science Report, http://nces.ed.gov/nationsreportcard/naepdata/).

[4]SEs for state NAEP scores vary from 1 to 3 points, and thus a 4-point difference would be statistically significant (U.S. Department of Education, National Center for Education Statistics, 2011c, 2009 NAEP Science Report, http://nces.ed.gov/nationsreportcard/naepdata/).

right quadrant of the plot, with the highest scores and average instructional time per week exceeding 3 hours per week (KY, VA, ND, Department of Defense Education Activity [DoDEA]). The Kentucky results (3.8 hours/week, 161 NAEP score) stand out among the states and provide a case example across a state of focused attention to science in the elementary curriculum. The prior NAEP Science results in 2005 showed similar results for Kentucky instructional time and student achievement (NAEP Science 2005 Report Card, http://nces.ed.gov/nationsreportcard/naepdata/).

Data are not available currently to analyze NAEP trends in science nationally or by state. NAEP Science established a new trend line with the 2009 assessment based on a new assessment framework. With the next science assessment in 2013, it will be possible to reanalyze the patterns of time and achievement nationally and by state over two reporting cycles.

Analysis of Question 3: Family Income, Instructional Time, and NAEP Science Score at Grade 4

The NAEP Science data for 2009 provide an opportunity to look more closely at the relationship of instructional time and student achievement at the state and national levels. A review of correlates with NAEP state aggregate scores indicated that student family income is an important measure to include in any analysis examining differences in average student achievement. The family income measure that is available with NAEP data is whether the student is eligible for free or reduced price school lunch, and the state aggregate measure is the percentage of students eligible for free/reduced price lunch.

A key research question addressed in this study is whether class time spent on science instruction in schools is related to the characteristics of the students, as indicated by student family income, that is, the percentage of students eligible for free/reduced lunch. Table 2 reports three aggregate measures for each state—the average hours of instructional time in science Grade 4 per week, the average NAEP score in 2009, and the percentage of students who are low income (eligible for free/reduced lunch). A number of prior research studies with NAEP data have found a strong relationship between the socioeconomic status of students and the NAEP score of students—for example, a higher percentage of low-income students is related to a lower NAEP average score (Barton, 2002; Barton & Coley, 2008; Braun, Coley, Jia, & Trapani, 2009; Darling-Hammond, 2010; Obed, Ault, Bentz, & Meskimen, 2001; Provosnik, Gonzales, & Miller, 2009; U.S. Department of Education, National Center for Education Statistics, 2011a). Figure 3 highlights the inverse relationship at the state level of the percentage of students on free/reduced lunch and average state 2009 NAEP Science score. For example, New Hampshire, a state with 22% of students from low-income families, has a NAEP score of 163, whereas Mississippi with 69% of students from low-income families has a score of 133, and the national average score of 149 includes 48% low-income students.[5]

The NAEP state-level data show that some states have changed the pattern of student background predicting the NAEP Science score, and Kentucky provides an example. In Table 3, it can be noted that Kentucky has a high average state NAEP Grade 4 science score of 161 on the Grade 4 assessment. Kentucky does have a relatively high percentage of low-income families (52%) and the Grade 4 classes in the state average a higher amount of time on science (3.8 hours/week). Oregon, on the other hand, is an example of a state with fewer low-income families (46%); teachers report a low average time on science instruction (1.9 hours/week), and the state has an average NAEP Science score of 151. By comparison, the national average NAEP Grade 4 science score is 149 and nationally 48%

[5]See Footnote 4 regarding statistical significance of NAEP score differences.

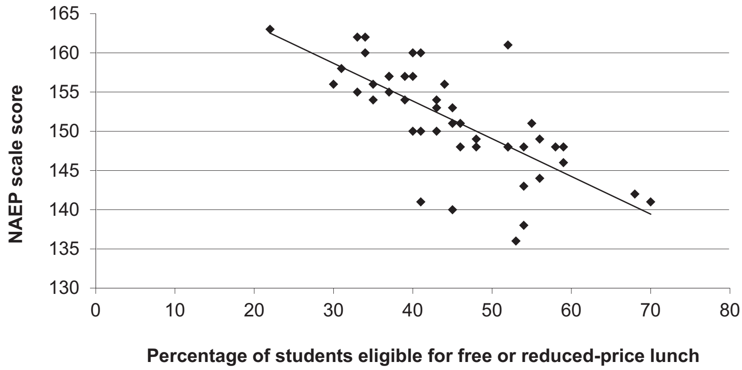

Figure 3. State NAEP Science score by percentage of students eligible for free or reduced-price lunch, Grade 4, 2009. Statistical significance: NAEP scores *SE* vary by state from 1 to 3 points; and a 4-point score difference is statistically significant. Source: U.S. Department of Education, NAEP 2009 Science Assessment. http://nces.ed.gov/nationsreportcard/naepdata/.

of students are low income and 2.8 hours is the average time spent on science instruction in Grade 4.

The results of the national analysis of NAEP scores by average hours of instruction per week and the percentage of students who are low income are displayed in Figure 4 and Table 3. The results show that more time on science means higher NAEP scores for all students and this pattern is consistent across categories of family income—eligible and not eligible for free/reduced lunch. The difference in NAEP scores is 12 points between students receiving less than 1 hour of science instruction and more than 4 hours of instruction per week. Thus, the data show that increased instructional time provides more opportunity for students to achieve and higher average student achievement. However, the data also show that instructional time by itself did not close the achievement gap on NAEP Science at Grade 4 between low-income and higher income students. For example, low-income students with the most instructional time (over 4 hours per week) average 138 on the NAEP scale, whereas students not eligible for free/reduced lunch and low instructional time (less than 1 hour per week) averaged 154 on the NAEP scale.

TABLE 3
NAEP Score by Science Class Time and Eligibility for Free/Reduced-Price Lunch, Grade 4, 2009

	Eligible		Not Eligible	
Science Class Time per Week (hours)	Average Scale Scores	*SE*	Average Scale Scores	*SE*
Less than 1.0	126	(1.4)	154	(1.5)
1.0–1.9	130	(1.1)	159	(0.9)
2.0–2.9	135	(0.6)	163	(0.5)
3.0–3.9	135	(0.6)	164	(0.5)
4.0 or more	138	(0.6)	166	(0.6)

Statistical significance: A 4-point NAEP score difference is statistically significant at the $p < .01$ level. *SE* for science hours/week vary from 0.2 to 0.4 hour.
Source: U.S. Department of Education, NAEP 2009 Science Assessment. http://nces.ed.gov/nationsreportcard/naepdata/.

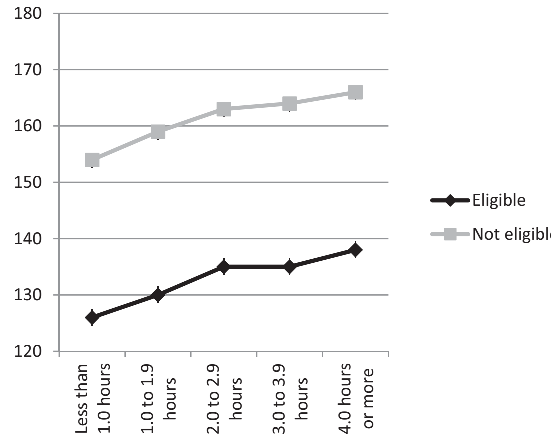

Figure 4. NAEP Science score by science class time and eligibility for free or reduced-price lunch, Grade 4, 2009. Vertical axis = NAEP score, horizontal axis = hours of science time per week. Statistical significance: A four-point NAEP score difference is statistically significant at the $p < .01$ level. *SE* for science hours/week vary from 0.2 to 0.4 hour. Source: U.S. Department of Education, NAEP 2009 Science Assessment. http://nces.ed.gov/nationsreportcard/naepdata/.

TABLE 4
Regression Coefficients for Relationship Between Science Instruction and Science Achievement

Predictor	*b*	*SE*
Science instructional time	1.45***	0.17
Poverty status (1 = FRPL)	– 25.37***	0.40
Intercept	162.33***	0.61
N	106,237	
R-sq	0.163	

Note: FRPL = free or reduced-price lunch.

Source: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, National Assessment of Educational Progress, 2009 Science Assessment special analysis.

To provide a more in-depth research analysis of the relationship of instructional time in science, student achievement score, and family background, a multiple regression analysis was conducted using 2009 NAEP Science student-level data and teacher-survey data.[6] Table 4 shows the results of the multivariate analysis of the NAEP scores from over 100,000 fourth-grade students together with teacher survey results. The results of the multivariate analysis showed that classroom instructional time on science has a positive relationship with NAEP Science achievement ($b = 1.45$, statistical significance $p < .01$), and the regression analysis showed that student poverty status (eligible for free or reduced lunch) had a negative relationship to achievement ($b = –25.37$, statistical significance $p < .01$). These results provide validity support for the pattern observed across states of the positive relationship of instructional time and student achievement in Grade 4 science

[6]By request, a special multiple regression analysis with NAEP student-level data ($N = 106{,}000+$) was conducted by NCES staff and provided by the U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics.

and confirmation that the pattern is consistent while accounting for student poverty status.[7] The two variables, instructional time and poverty status, account for a small amount of the variance in the NAEP Science scale scores (R-sq $= 0.163$), which indicates that there are other confounding factors not accounted for. Other variables related to student classroom, school, and home environments may further explain the relationship between instruction and performance.

CONCLUSIONS

The analyses of instructional time in elementary science have added to knowledge in the field regarding the degree of variation in science instruction and the effects on students. First, the study analyzed trends over time based on SASS data from elementary teachers of Grades 1–4 and the data showed that science instruction for students in these grades declined from 1994 to 2008. Time for elementary science declined from 2000 to 2008, despite the overall increased time spent per week on core academic subjects during that period. Elementary science instruction in 2008 was at the lowest number of hours per week as a national average since trend data on the measure began in 1988. Time spent in classroom instruction in science declined during the time period of increased state and federal accountability testing and reporting, particularly in the period 2000–2008. Instructional time in elementary classes for language arts reading and mathematics has increased whereas instructional time on science continued to decline. On a daily basis, elementary classes in 2008 were spending an average of only 28 minutes on science, whereas they were spending over 1 hour per day on mathematics and more than 2 hours per day on language arts and reading.

The second research question in the study focused on elementary instruction and student achievement at Grade 4. The NAEP data from Grade 4 teachers in 2009 revealed wide variation in the amount of class time spent per week on science instruction across the states. The average time on science instruction reported by teachers in 2009 showed that the time for science in several states was almost twice the average instructional time provided in other states. In the states with the highest reported time on science, students had an average of over 3 hours per week on science in Grade 4, whereas less than 2 hours per week was spent on science instruction in other states. With NAEP Grade 4 Science Assessment data, it was possible to examine the relationship between instructional time per week and student achievement scores on NAEP Science. Using average time per state and the state average NAEP scale score, our analysis showed a positive relationship between instructional time and student achievement, that is, more instructional time made a difference for student achievement. Organizing NAEP achievement scores by instructional time indicated that students in the classes with the highest amount of class time per week (4 hours) had average NAEP achievement scores 12 points higher than students in the classes with the lowest amount of class time (1 hour).

The third area of inquiry in the study was analysis of the relationship of student achievement and instructional time while accounting for student family backgrounds. Prior research on student achievement in science and other core school subjects showed that student scores on standardized tests, including NAEP, are related to the socioeconomic status of the

[7]Grade 8 NAEP Science scores were also analyzed with multiple regression using the same variables, and no relationship was found between instructional time and student achievement score. This result can be attributed to the small variation in instructional time between classrooms, teachers, and states. At Grade 8, time for instruction in each subject is largely established by length of class periods that are set by state, district, or school policies (Center on Education Policy, 2008; Stillman & Blank, 2009).

student's family. Research studies have analyzed the degree to which the "achievement gap" between students from lower and higher income family backgrounds is reduced by educational initiatives. In this study, using NAEP Grade 4 science data, the key question examined was the effect of science instructional time on student achievement when the family background of students is held constant. The results of multiple regression analysis showed that there was a positive effect of instructional time on student achievement in the NAEP Science Grade 4 results. Students with the most time on science instruction had significantly better scores than those with less time and this gives positive weight to the argument for the importance of class time to be spent on science. However, even though the time in instruction was shown to improve the student achievement in Grade 4 science, an achievement gap is continuing to be present as of 2009 between students from low-income families and the students from more advantaged family backgrounds. In the aggregate, time of instruction did not by itself overcome student family background effects enough to report a significant reduction in the achievement gap. The continuing gap in science achievement at Grade 4 is a significant cause for concern, especially in states and schools where there is less focus on science education at the elementary level. It is possible that in this era of test-based accountability, many schools with more low-income students decided to strategically focus more effort and time on language arts and mathematics instruction to meet annual performance targets, and science instruction may be given more priority when achievement in these subjects has improved.

IMPLICATIONS

At a time when proficiency in science is more important than ever, the findings on overall trends in allocation of classroom time are troubling. The findings of this analysis on science time in elementary classrooms, together with the long record of prior research on the importance of adequate instructional time, point to a conclusion that advancing student interest in pursuing study of science and study in related fields may be difficult. Lack of adequate time for instruction in elementary grades is likely to decrease the chances of closing the achievement gap in later grades for students from low-income families. The findings here are *not* intended to suggest that time is the only factor in improving teaching and learning in science or performance on NAEP—other variables including teaching practices, curriculum, and teacher preparation also need to be considered. Although a number of factors in school contribute to students' performance, the analyses in this study suggest that at the elementary school level, time on science instruction does make a difference. The national data trends over the past two decades show increased time and attention on language arts reading and mathematics in relation to the overall instructional day, and less time in elementary classrooms, Grades 1–4, on science. It is possible that this trend may be a contributing factor in the continuing achievement gap in science and the wide variation in student performance.

The analysis results for NAEP Grade 4 Science Assessment show wide variation among states in elementary science instructional time and in student achievement. A further step in analysis at the state level would be to examine differences in state policies and state-level guidance regarding science curriculum, professional development, and other policies. Further analyses by state would ask, Is there a combination of policies across states with higher scores on NAEP that show a similar pattern? A science role in state accountability does appear to make a difference. One recent study found that the 12 states (including Kentucky) that include science test results in school accountability scores had significantly higher achievement on NAEP Science than other states, even when controlling for prior student performance, student background, and other variables (Judson, 2012), and this finding provides support for educators seeking expansion of science assessment results as a required component of school accountability.

The relationship of state policies and patterns in allocation of time can be further analyzed with the next cycle of NAEP Science Assessments in 2013. A trend analysis for NAEP Grade 4 science achievement was not possible for this paper given the change in NAEP assessment frameworks. However, the question of time for science instructional time asked of teachers in 2005 was the same item used in 2009. A review of the data on average class time (from NAEP Data Explorer http://nces.ed.gov/nationsreportcard/naepdata/) showed that state averages for the average time on science per week in 2005 were very similar to the averages for 2009, and the data indicate validation of the state differences in average time reported for 2009.

Another question that could be examined in further research is *how* teachers in different states use classroom time, and how curriculum across subjects is organized to meet expected goals. Currently, most states are working to implement the Common Core State Standards and this will likely mean, for many schools and teachers, a coming transition in local curriculum and classroom instruction in ELA and mathematics for Grades K–12 (Council of Chief State School Officers and NGA, 2010). As states move forward with development and implementation of the Next Generation Science Standards (Achieve, 2013), based on the NRC Framework for K-12 Science Education (2012), it will be important to consider how instruction and curriculum in each grade can better use available time to teach across the sets of standards. Many states are planning curriculum under the literacy standards of the Common Core that can lead to integrated approaches to instruction across language arts, mathematics, science, social studies, and technology.

The results of the data and analyses presented in this research raise important policy issues concerning the status of science education in the elementary curriculum. Efforts to reinforce and improve elementary science instruction over the past 20 years have happened during the era of K-12 education reform highlighted by national and state standards and raised the importance of assessments and accountability. It is likely that current policies focused on school accountability have raised the importance of instructional time and emphasis on reading and mathematics, particularly in schools and states with high proportions of students from low-income families.

The findings of the research indicate that new policy approaches, focused on relevance and need for science in the elementary grades may be called for, particularly as reauthorization of the federal ESEA is being considered by the Congress. If science is to continue as a core academic subject with expected standards of learning and performance for all students, policy changes and additions may be needed nationally, in states, and in school districts, to ensure that conditions in schools and classrooms will lead toward students having access to quality science teaching, curriculum, and materials. This research focused on time in the school day for science education, how it has changed over time, and impact of time on student achievement. One policy solution may be to ensure that the schools and teachers include adequate time for science instruction. The evidence from this research shows wide variation in allocation of elementary class time to core subjects, and policy changes may be needed to more closely define for schools and teachers the time expected per subject in each grade.

A second type of policy solution may be to ensure that critical standards for learning in science at each grade are taught in classrooms. That is, instead of tracking class time, teachers would report on science standards taught each week. As states and districts consider strategies for implementation of the *Next Generation Science Standards*, it may be critical to plan how schools and teachers will be accountable for the standards. With the wave of new standards being adopted by states in mathematics, ELA, and science, and assuming the current length of the school day continues, the key question for reporting from teachers may be what content gets taught relevant to the standards across each subject, rather than how much time is spent on each subject. Currently, accountability in education relies very heavily on standardized, end-of-year assessments for students. The question of accountability for delivering instruction that aligns to expected standards for teaching and learning may be an appropriate development for improved school accountability.

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