UNDERSTANDING ELEMENTARY TEACHERS' USE OF SCIENCE TEACHING TIME: LESSONS FROM THE BIG SKY SCIENCE PARTNERSHIP

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Introduction

The Big Sky Science Partnership (BSSP) serves grades K-8 science teachers in schools on and near three American Indian reservations in Montana. The BSSP is led by Salish Kootenai College, in partnership with Montana State University, the University of Montana, and numerous, mostly rural, school districts. This article presents how we addressed the project's need to know how much time teachers in the Partnership had available to teach science, how that time was distributed and used, and key influences on teachers' decisions regarding science teaching time. During the first full year of professional development activities in our Partnership, 2007-2008, it became apparent that some teachers in the program allocated little time to science instruction and that their perception was that this was for reasons beyond their control. This first came to our attention in conversations with the teachers, and when an unexpected number of baseline observations scheduled well in advance by staff were of lessons that were either greatly abbreviated, sometimes lasting just fifteen minutes, or on non-science topics.

This disheartening circumstance appeared to be at odds with staff observations and external evaluators' reports showing that teachers found the face-to-face and on-line workshops and graduate coursework on science teaching relevant and valuable. Indeed, in the spring of this first full year of operation, twenty-two of the forty-five teachers served by the project voluntarily increased their workload by entering a Master of Science in Science Education program that added twelve graduate credits, distributed over three years, to the twenty-four earth science, astronomy, and physics credits they were already earning through the BSSP.

How could it be, we wondered, that teachers who diligently attended science workshops, read and posted on-line, and many of whom exposed themselves to greater rigors by joining the master's program, nonetheless reported having very limited time for science instruction? Speculation abounded. Potential culprits included the following issues: historical primacy of reading/language arts and mathematics in the elementary curriculum, an imbalance that has

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increased significantly since the federal No Child Left Behind (NCLB) legislation took effect in 2002; lack of resources to teach science in certain Partnership schools, even down to the absence of any hands-on materials or textbooks; and, teachers' level of preparation and confidence to teach science [1]. Our immediate concerns included the likelihood that teachers lacking regular opportunities to teach science would not benefit from the deeper learning that occurs when actually teaching a topic, the realization that well-attended workshops and popular on-line coursework would be pointless if these were only marginally increasing grade school students' opportunities to learn science, and the apprehension that if we didn't learn more about this situation quickly, our opportunity to maximize the impact of our Partnership would disappear.

Consequently, in early 2008, staff working with the Partnership's eastern cohort of fourteen teachers agreed to analyze data already being gathered by the project evaluation, and to collect additional forms of data to better understand the teachers' allocation and use of instructional time for science, as well as influences on their decisions in this realm. This article presents what we learned about methods for monitoring instructional time for science, how the project benefited from the first cycle of data collection, and implications for other partnerships, school districts, and organizations working to further elementary school science.

Relevant Literature

Our first step was to study the literature to learn what is known about instructional time for science, and how to frame and measure it. Our hunch that today's elementary schools are focusing more time on reading/language arts and mathematics, often by subtracting from other academic areas, was confirmed by a national survey study conducted by the Center on Education Policy (CEP) [1, 2]. The Center identified a sample of 491 school districts varying according to size, location, demographics, presence of at least one school identified for improvement under state guidelines in response to federal No Child Left Behind legislation, and other factors. Of the 349 districts completing the CEP survey, many matched the profile of the seven districts served by the BSSP eastern cohort teachers in that they were rural (116), small (192), and included at least one school identified for improvement (151). A comparison of district survey results from 2001-2002, one year prior to implementation of NCLB, to 2006-2007 showed that 58% of the districts increased instructional time for reading/language arts, and that the average gain was 142 minutes per week (see Table 1). Similarly, 45% of responding districts increased instructional time for mathematics, and did so by an average of 89 minutes per week. Those districts increasing instructional time for reading/language arts and/or mathematics decreased the time allowed for other subject areas and recess by an average of 145 minutes per week. For districts selecting science for reduction, the decrease averaged 75 minutes per week, but the magnitude of such changes varied widely. For example, more than half of the districts decreasing science instruction even minimally did so by 75 to 150 minutes per week (see Table 2).

Table 1
Changes from 2001-02 to 2006-07 in Instructional Time for Elementary School Science for Districts Reporting Increases in Reading/Language Arts and Mathematics

Subject	Average total instructional time pre-NCLB (minutes per week)	Average total instructional time post-NCLB (minutes per week)	Average change (minutes per week)	*Average change as a % of total instructional time
Reading/ Language Arts	378 (6.3 hrs)	520 (8.6 hrs)	+142 (2.4 hrs)	+ 47%*
Mathematics	264 (4.4 hrs)	352 (5.9 hrs)	+ 88 (1.5 hrs)	+ 33%*
Science	226 (3.7 hrs)	152 (2.5 hrs)	- 74 (1.2 hrs)	- 43%*

*Adapted from McMurrer (2008) [1].

The percentages in the final column were first calculated for each district, then weighted according to how many national districts each responding district represented, and finally averaged across districts to generate the numbers reported here. The methodology link for McMurrer can be found on the Center on Education Policy's website [2].

Table 2
Magnitude of Decreases Since 2001-2002 in Instructional Time for Elementary Science

Subject	Fewer than 25 minutes per week	25-49 minutes per week	50-74 minutes per week	75-149 minutes per week	150 minutes per week or more
Science	3%	15%	29%	42%	11%

*Adapted from McMurrer (2008) [1].

How do these findings compare with those from other studies, and what methodologies did the others use? The *Teacher Questionnaire Schools and Staffing Survey* (*SASS*) is administered periodically, in intervals ranging from three to six years, by the National Center for Education Statistics (NCES), U.S. Department of Education [3]. Since 1987, the *Teacher Questionnaire SASS* has included an item that asks elementary teachers working in a self-contained classroom, "During your most recent full week of teaching, approximately how many hours did you spend teaching this subject in this school?" For each subject area, respondents may answer "none" or provide a response rounded to the nearest hour [3]. First through fourth grade teachers completing the *SASS* during the 2003-2004 school year reported spending an average of 2.3 hours per week on science instruction, a decline of 18 minutes from the 2.6 hours per week reported by respondents to the next most recent *SASS* in 1999-2000 [4]. The *SASS* results show that the average science teaching time per week across all 1,596 elementary teachers included in the 2003-2004 sample was 2.04 hours per week (SD=2.25), with 31.9% reporting that they had not taught science the most recent full week of teaching, and the remainder reporting 1 hour (14.1%), 2 hours (17.5%), 3 hours (17.2%) or 4 or more hours (19.4%). Results for 2007-2008 are not yet available [5].

These figures are not dissimilar from those reported by fourth grade teachers in the United States responding to the Trends in International Mathematics and Science Study (TIMSS) in 2003 and 2007 [6, 7]. Each teacher of a class included in the TIMSS assessment completes a teacher questionnaire [7]. They are first asked, "Is science taught mainly as a separate subject to students in the TIMSS class?" If the response is "yes," the teacher is asked, "How many minutes per week do you teach science to the fourth grade students in the TIMSS class?" If "no," the teacher is asked to "estimate the number of minutes per week that you spend on science topics with the fourth grade students in the TIMSS class." Results from 2003 and 2007 are shown in Table 3. In 2003, 85.7% of respondents reported teaching science as a separate subject, and spending an average of 143.1 minutes per week (2.38 hours) on science instruction [6]. This figure was considerably higher than the 122.7 minutes per week (2.04 hours) reported by the 14.3% of teachers who taught some science, but not as a separate subject. In 2007, the proportion of respondents teaching science as a separate subject had risen to 91.0%, and the average minutes per week they devoted to science had increased to 150.5 minutes per week (2.51 hours) [8]. In the same year, the 9% of teachers who blended science with other subject areas reported devoting 122.5 minutes per week (2.04 hours) to science, an almost identical response to that in 2003.

Table 3
Instructional Time for Science Reported by Fourth Grade Teachers on the 2003 and 2007 TIMSS

Science taught as separate subject			Some science taught, but not as separate subject		
Percentage of respondents	Average instructional time in minutes	Median	Percentage of respondents	Average instructional time in minutes	Median
2003					
85.7%	143.1 (2.38 hrs)	135 (2.25 hrs)	14.3%	122.7 (2.04 hrs)	100 (1.67 hrs)
2007					
91.0%	150.5 (2.51 hrs)	150.0 (2.5 hrs)	9.0%	122.5 (2.04 hrs)	100 (1.67 hrs)

The National Assessment of Educational Progress (NAEP) is administered by the NCES every few years, with science last assessed in 2005. Part IV (Science) of the NAEP *Teacher Background Questionnaire* includes a question for fourth grade teachers about instructional time for science [9]. The teachers are asked, "About how much time in total do you spend with this class on science instruction in a typical week?" They must then select one of five responses ranging from "Less than 1 hour" to "4 hours or more." Their answers to this question on the 2005 NAEP are shown in Table 4 [10]. The modal response of 2-2.9 hours per week is within the range of the responses reported by the studies above, including the CEP survey (2.5 hours per week), the *SASS* (2.04 hours per week), and the TIMSS (2.51 hours when science is taught separately, otherwise 2.04 hours).

The National Center for Education Statistics, which oversees the NAEP, allows researchers to perform simple analyses of NAEP data using the on-line NAEP Data Explorer tool. This resource allowed us to examine the relationship between the time fourth grade teachers devoted to science and the performance of their students on the NAEP. The average NAEP fourth grade Scale Score for science was 152 in 2005, which was close to the median score of 153 the same year, and significantly higher than the 147 average score achieved by fourth graders in 2000 [11]. As a group, students receiving at least 2-2.9 hours of science instruction met or exceeded the national average Scale Score on the NAEP in 2005, and those receiving less science instruction scored below the average (see Table 4). Table 5 provides the results of statistical analysis of these differences. This indicates that students receiving the least science instruction (ranging from less than an hour per week up to 1-1.9 hours weekly) performed significantly lower on the NAEP science assessment than students in the three groups receiving more science instruction (p = 0.0000) [10]. There was also a significant difference in performance (p = .0159) between students receiving less than an hour of science per week, who attained an average score of 141, and those receiving 1-1.9 hours of science weekly, whose average score was 145. Yet the performance differences between the three groups receiving 2-2.9 hours or more science instruction weekly were slight, and statistically significant in only one case. This suggests that when instructional time for science reaches a certain level, apparently in the vicinity of 2-3 hours per week for fourth graders, merely increasing time for science does not affect student learning, at least not in ways measured by the NAEP.

Table 4
Instructional Time for Science Reported by Fourth Grade Teachers on the 2005 NAEP

Hours per week for science instruction	Percentage of fourth grade teacher respondents	Average fourth grade science Scale Score (out of 300)	Standard Error
Less than 1 hour	6	141	(1.4)
1-1.9 hours	17	145	(0.7)
2-2.9 hours	34	152	(0.5)
3-3.9 hours	27	153	(0.6)
4 hours or more	17	154	(0.7)

Table 5
Significance of Differences in NAEP Fourth Grade Science Scale Score by Instructional Time for Science

Hours per week for science instruction	Less than 1 hour	1-1.9 hours	2-2.9 hours	3-3.9 hours
1-1.9 hours	*Diff = 5 > p = 0.0159			
2-2.9 hours	Diff = 11 > p = 0.0000	Diff = 7 > p = 0.0000		
3-3.9 hours	Diff = 12 >	Diff = 8 >	Diff = 1 =	

	p = 0.0000	p = 0.0000	p = 0.1808	
4 hours or more	*Diff = 14 > p = 0.0000	Diff = 9 > p = 0.0000	*Diff = 3 > p = 0.0028	*Diff = 2 = p = 0.0754

> Significantly higher, = No significant difference.
* Differences between Scale Scores tabulated for Table 5 sometimes vary from the simple arithmetical differences between any pair of average Scale Scores reported in Table 4 due to variability in the original data sets.

The *2000 National Survey of Science and Mathematics Education* was designed and carried out by Horizon Research, Incorporated [12]. Fulp reports results from a national sample of 655 K-5 teachers completing the survey [13]. Elementary teachers were asked to respond to the following prompt regarding instruction in each of four subject areas, including science: "In a typical week, how many days do you have lessons on each of the following subjects, and how many minutes long is an average lesson?" The K-2 teachers in the sample reported spending 21 minutes per day (1.75 hours per week) on science instruction, compared to 30 minutes per day (2.5 hours per week) for the grades 3-5 teachers, and 25 minutes per day (2.1 hours per week) for all grades K-5 respondents combined. These responses, gathered two years prior to implementation of NCLB, are consistent with the range reported in the other national and international studies described above. The slightly low overall average (2.1 hours per week) is closest to that reported for the *SASS*. In both instances, this may be attributed to the effect of primary grade teachers, who typically teach science less frequently than teachers at other levels, and were not included in the other studies.

The Council of Chief State School Officers (CCSSO) and the Wisconsin Center for Education Research (WCER) developed the Surveys of Enacted Curriculum® (SEC®) in 1999, piloting it in a large field study involving over 600 teachers in eleven states [14]. The SEC® is currently used in numerous states and school districts. The "Survey of Instructional Practices: Teacher Survey, Grades K-8 Science" is completed at the end of each school year by the teachers in our Partnership [15]. Regarding time allocated for science, teachers are asked, "During a typical week, approximately how many hours will the target class spend in science instruction?" and must round their answer to the nearest hour. They are also asked, "How many weeks total will the target science class/course meet for this school year?" and must choose between 1-12, 13-24, and 25-36 weeks. A third item queries, "What is the average length of each class period for the targeted science class?" with response options ranging from 30 minutes to 2 hours. As we learned once SEC® data for our own Partnership was in hand, asking teachers to describe the time devoted to science in several different ways was critical to obtaining a reasonably accurate understanding of their practice. Knowing only the average hours per week devoted to science would have provided a highly inaccurate picture for the many BSSP teachers who reported not teaching any science for one-third to two-thirds of the school year. Yet even with three distinct data points regarding science teaching time provided by the SEC®, we needed to know more. For example, science lesson length is an important consideration for reform oriented projects like the BSSP, since longer lesson periods facilitate inquiry science. Yet the shortest SEC® response option for lesson length is 30 minutes—two to three times longer than many science lessons recorded in our project.

Our review also revealed extensive literature on internal and external influences on teachers' decisions about science instruction. One factor often cited in the literature is teachers' beliefs about their ability to teach a particular subject, such as science. Such self-efficacy or capability beliefs are among the best indicators of decisions teachers make about their professional practice [16-18]. Soodak and Podell comment that decisions about practice often center on a highly specific capability belief: teachers' sense of their ability to bring about change in their students [19]. Woodbury and Gess-Newsome comment that teachers' beliefs, or what they term "teacher thinking," is shaped by personal factors that affect practice, among them the nature and extent of pre-service preparation and ongoing professional development [20]. Fullan and Hargreaves note that teacher thinking is influenced by teachers' earlier life experiences, current life and career stage, values, attitudes, confidence, and gender [21]. Ford describes teachers' context beliefs regarding how supportive teachers believe the environment will be to the success of a given instructional decision, such as teaching science [18]. Instructors may weigh factors within the school, such as physical space, scheduling, equipment availability, or administrator's and colleagues' opinions, as well as factors outside of school, such as anticipated opposition or support from parents and the local community, or from policies at the district, state or national level. Weiss, Banilower, McMahon and Smith found that structural factors, such as degree of access to basic resources including textbooks and other science teaching materials, access to technology, and adequacy of time for educators to plan, teach or learn more science, were often cited in the teachers' responses to the *National Survey of Science and Mathematics Education* [12]. As the literature suggests, a range of internal and external factors soon emerged as influential in the decisions BSSP teachers made about science instruction.

Among the data collection instruments described earlier, only the SEC® explicitly addresses influences on science instruction. Respondents to the Teacher Survey are asked to, "indicate the degree to which each of the following influences what you teach in the target science class." The teachers are then provided with ten choices including state or district curriculum framework or content standards, state or district tests or results, *National Science Education Standards*, textbook or instructional materials, pre-service preparation experience, the special needs of students, and the influences of parents and community [22].

We first determined to investigate how much time the elementary teachers in our Partnership were able to devote to science teaching, how this time was distributed, and the influences guiding the teachers' decisions about time allocation for science. Needless to say, even in the absence of a reasonable amount of time set aside for science instruction, a dual focus on the quality of the learning experiences provided is necessary. This is analogous to ensuring that students are not only receiving enough calories, but that their caloric intake is nutritionally balanced to fill their growth and energy needs. This article focuses on the calorie-equivalent question, "Are students getting enough science?"—a simple question that is surprisingly difficult to answer well. We also describe our current efforts to answer the quality question, "Are students receiving the right science experiences?" Clearly, getting enough science and a balanced blend of experiences are both needed, even if the issues are occasionally examined independently as part of broader research endeavors.

Methods

To investigate teachers' allocation of time for science, and what influences it, we selected a mixed methods approach for the overall research [23, 24]. To paraphrase Denzin and Lincoln, our purpose in using multiple approaches to data collection and analysis was to capture as much of the reality as possible, even if this meant confirming the possibility that science teaching occupied a minor place in BSSP teachers' classrooms [25]. All fourteen teachers in the first BSSP eastern cohort were invited to participate in this component of the project's data collection, and ten agreed to do so during the 2007-2008 school year. Seven of the teachers were assigned to self-contained, first through fifth grade classrooms. The other three teachers included a technology specialist, a reading/language arts and mathematics specialist, and a special needs teacher. These three teachers worked with different classes or small groups throughout the day, and were permitted by their administrators to integrate science into their instruction to a certain degree. The ten teachers worked in seven different schools on or near two American Indian reservations, and these included five public schools, one tribal school, and a private Catholic school.

We gathered teachers' perspectives through two survey instruments, one administered at the end of the 2007 and 2008 school years, and the other completed weekly during an eight-week period in Spring 2008. We explored issues that emerged through the surveys during teacher interviews conducted in early Summer 2008. We also used the results of a baseline classroom observation of each teacher and science portfolios all BSSP teachers completed in Spring 2008 to extend our understanding of how Partnership teachers allocated time for science, and the factors driving their decisions. Each of the five data collection tools described below, including three developed and widely tested by other national or regional projects, and two that were created or adapted for the BSSP, contributed significantly to our investigation.

The Surveys of Enacted Curriculum® (SEC®), developed by the Council of Chief State Schools Officers (CCSSO), the Wisconsin Center for Education Research (WCER), and state partners in 1999, was introduced earlier in this article. The surveys were intended to provide "reliable, objective data on instructional practices and subject content" as reported by teachers [26]. Some items were adapted from previous studies or instruments including "Reform up Close," the *National Survey of Science and Mathematics Education*, the *Third International Mathematics and Science Study* teacher questionnaire, and the NAEP teacher background surveys [12, 27, 28]. In a study on an early version of the SEC®, Porter found that teachers' responses on surveys administered infrequently (once a semester or once a year) matched the results of daily logs or classroom observations involving the same teachers reasonably well [27]. Thus, the SEC® team determined that teacher recall was acceptable on surveys administered annually. Yet when student data was collected in 1999 to determine the consistency between student and teacher reports on science instruction in the same classrooms, the results were mixed. There were significant positive correlations between student and teacher responses for just 57% of the items, compared to positive correlations for 94% of the items on corresponding surveys in mathematics [14]. This discrepancy may be due to more variability in teaching patterns in science than in mathematics, making accurate characterization of instructional content, methods, or even the classroom time allowed for science, more difficult for teachers and students to pin down.

The Big Sky Science Partnership teachers completed the entire SEC® "Survey of Instructional Practices: Teacher Survey, Grades K-8 Science" at the end of the 2006-2007 and 2007-2008 school years [15]. We asked the teachers to respond in terms of the school year that had just ended. The items regarding time allocated to science instruction and what influences science instruction are of particular interest in this study.

The "Weekly Teaching Survey" (WTS) is a Likert-style questionnaire developed for this study. The survey focused on four components of science instruction: teaching practice, teaching time, culturally responsive practices, and influences on teaching. A number of the twenty-four items on the WTS were selected or adapted from the SEC®, as well as the "Cultural Competency Survey" designed by Regina Sievert, Director of the Indigenous Math and Science Institute, Salish Kootenai College, the lead institution for the BSSP. The Cultural Competency Survey was used to gauge culturally responsive practice among BSSP teachers, as teachers of American Indian students. The first version of the survey was piloted for three weeks by a dozen elementary school teachers not associated with the BSSP, and the survey was revised based on their comments regarding clarity of the questions and format, and the time needed to respond. Our sample of ten BSSP eastern cohort teachers completed the WTS during eight consecutive weeks in Spring 2008. Their responses regarding science teaching time and relevant influences will be reported in this article.

The *Classroom Observation Protocol (COP)* developed by Horizon Research in 2005 is designed to provide accurate information about the alignment of instruction with standards-based practice in science and mathematics classrooms [29]. The BSSP science and education staff have attended formal *COP* observer training and conduct annual observations of every teacher in the program. The Spring 2007 and 2008 observations were used to provide additional context regarding the time BSSP teachers allocate for science.

The "Scoop Notebook" is a data tool that uses classroom artifacts and teacher reflections to characterize teachers' science instruction with respect to key dimensions of reform-oriented practice. This approach was developed by Hilda Borko and colleagues at the University of Colorado at Boulder, University of California, Los Angeles and RAND® Corporation [30]. A pilot study was conducted in 2004 involving thirty-nine middle school science teachers in two states. Each teacher completed a Scoop Notebook, modified for the BSSP, to document instruction for a lesson series, and was observed two to three times by the same researcher. Some of the teachers were also audio taped, thus providing samples of classroom discourse. The data sources were scored independently along eleven dimensions associated with reform oriented science instruction. The design team concluded that the Scoop Notebook is a "reasonable" tool for describing instructional practice, especially for dimensions that are unlikely to vary greatly from day to day. When the Scoop ratings were compared to "gold standard" ratings carried out by the observer assigned to a given teacher after reviewing all the information available about that teacher's practice, the correspondence was slightly stronger. As part of our Partnership's formal evaluation, each teacher completes a Scoop Notebook once a year; this includes a timeline, activity plans, student work samples and other documentation for three or more lessons, all focused on a single science topic. Through the Scoop, we were able to obtain an additional snapshot of the BSSP teacher's practice at the end of the Partnership's first full year of professional development in Spring 2008. Since the teachers knew that at least one Scoop lesson per teacher would be observed by project staff, we conjectured that various lesson dimensions, including the time necessary for a lesson, would reflect the teachers' visions of "best practice" for science teaching.

Interviews were conducted with each teacher in the study sample in early Summer 2008 after other forms of data had been gathered. The interviews were semi-structured, with questions relatively standardized, but open-ended. The interview themes included science teaching time, science teaching practice, connections of science with historical or contemporary American Indian culture, and influences on science teaching time and practice. Some questions were adapted from a protocol designed to gauge teachers' beliefs about science as inquiry and science teaching developed by Roehrig and Luft in 2006 and from the *COP* post-observation interview [29, 31]. In this study, the interviews were used, in conjunction with other data collection methods, to gather descriptive information in the participants' own words.

Findings

This study was designed in part to help our Partnership understand the amount of time elementary teacher participants are able to devote to science teaching, and how this time is distributed. Each of our data sources contributed to this understanding. Time is an educational resource that always seems to be in short supply, and if we want to improve science instruction, then partnerships like BSSP need to influence the current distribution of time for science. From the SEC® end-of-school-year responses in 2007 and 2008, we gleaned estimates from the ten teachers in our sample regarding how many hours during a typical week each teacher's class spent learning science. Each year, four to five of the teachers selected 1 hour per week, two to three teachers selected 2 hours, and the remaining one to two teachers selected 3 or 4 hours per week, with one response omitted in 2007 (see Figure 1). This yields a mean response of 1.8 to 1.9 hours per week for science in 2007 and 2008, respectively. On the SEC®, the teachers also estimated the average length of science lessons taught during the year that had just ended, with six teachers choosing the shortest option, 30-40 minutes in 2007 and 2008, one to two teachers selecting 41-50 minutes, and two to three teachers stating that lesson length varied due to scheduling, integrated instruction, or other factors (see Figure 2).

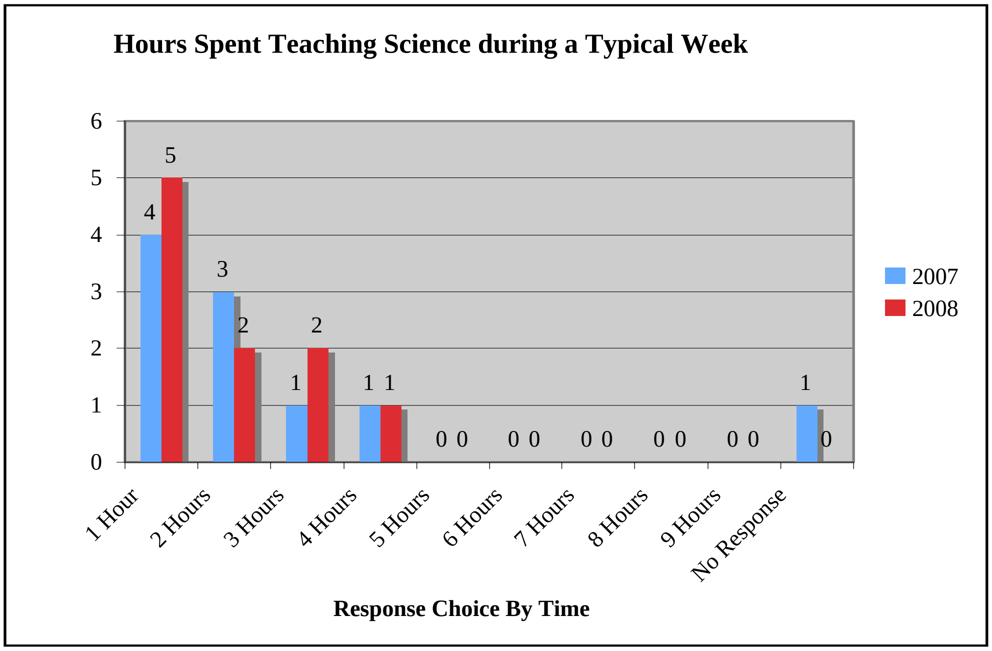

Figure 1. Estimated hours per week for science—SEC® responses (*n* =10).

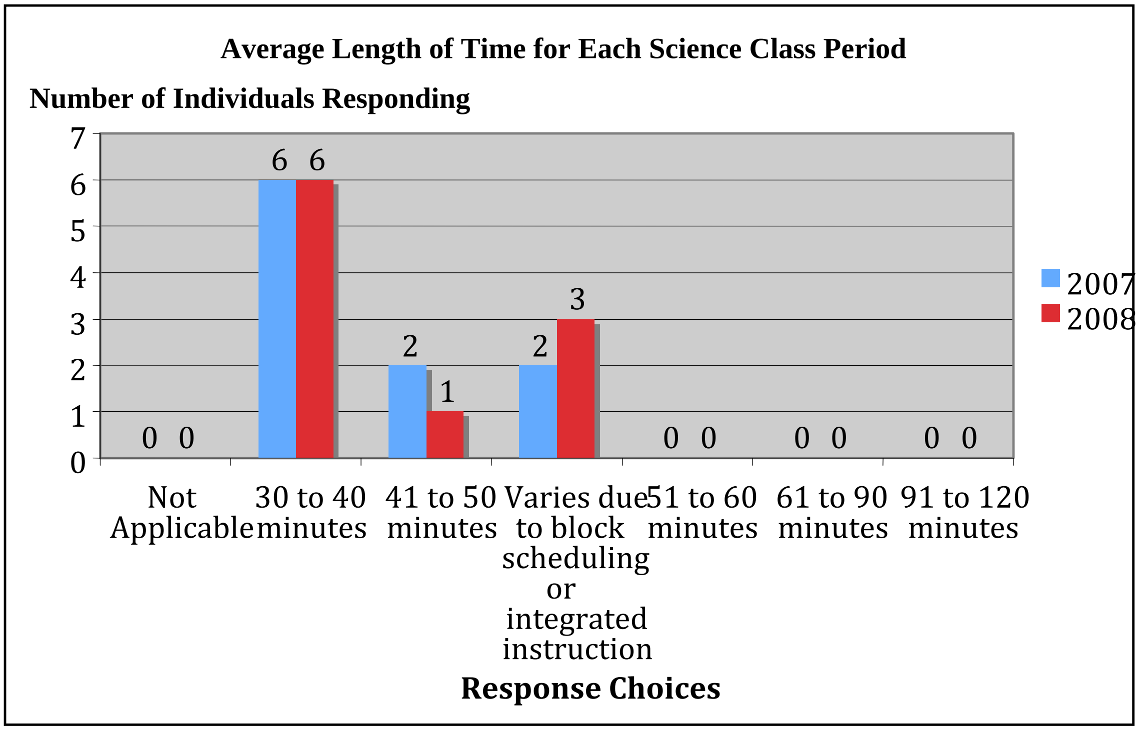

Figure 2. Average minutes per science lesson—SEC® responses (*n* =10).

Perhaps the most telling results from the SEC® concerned the number of weeks devoted to science instruction each year. A majority of states and districts still stipulate a 180-day school year, with the days spread across about forty weeks when holidays are taken into account. In each of the two years we administered the SEC®, two to three teachers indicated that they taught science during 1-12 weeks of the school year, six to seven teachers selected 13-24 weeks, none selected 25-36 weeks, and one teacher did not respond each year (see Figure 3). If we postulate that the two-thirds of our sample selecting the 13-24 week response option actually taught science for twenty weeks per year on average, multiplying this by the 1.9 hours per week for science reported by the teachers in June 2008, we can estimate that those teachers were able to spend an average of 38 hours that year on science instruction, far lower than the 76 hours we might assume based on a forty-week school year. Using the same heuristic, we can estimate that the two teachers selecting the 1-12 weeks response taught science for 22.3 hours or less during 2007-2008. Information of this nature can be of tremendous importance in helping a partnership like the BSSP plan how to proceed with “eyes wide open” regarding the degree of focus on science in Partnership classrooms.

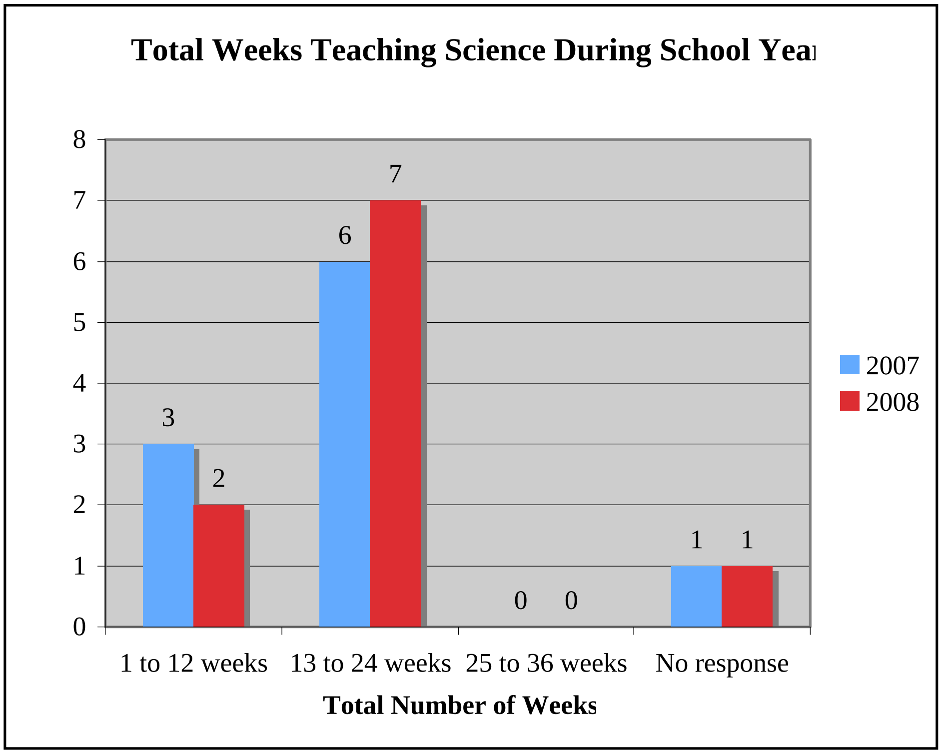

Figure 3. Estimated weeks per year for science (*n* =10).

To summarize, the SEC® results indicated that the elementary teachers in the BSSP eastern cohort typically teach science for 1.8 to 1.9 hours per week for somewhere between thirteen and twenty-four weeks of the school year, or roughly 25-46 hours per year, and that a typical lesson lasts 30-40 minutes.

What more did we learn by supplementing the retrospective SEC® with the WTS, an electronic survey developed by the project and completed by ten eastern cohort teachers for eight weeks in Spring 2008? The WTS contributed several unique insights. First of all, the WTS clearly showed the great variation in the time devoted to science teaching per week when making comparisons across instructors, or examining an individual teacher's practice across the eight-week data collection period. Although we purposely scheduled the WTS during a lull in the school year when State testing was over in most schools and end-of-year schedule disruptions were still distant, WTC results illustrate that time devoted to science was far from steady or stable. Table 5 shows the wide range in time allowed for science in the classrooms of the ten teachers filling out the weekly surveys. The teachers recorded the number of minutes for each science lesson at the end of the week, and these results were converted to hours per week for science to allow comparisons with SEC® results. The WTS data yielded an average time for science instruction of 1.64 (SD = 1.35) hours per week. At times, the across-teacher differences are easy to interpret. For example, "Jessica," "Sarah," and "Tiffany" taught science a modest .63, .81, and 1.07 hours per week—understandable given that they are the only grades 1-2 teachers in our sample, although far lower than the 1.75 hours per week found for primary teachers in one national study [13]. "Kimberly" taught science even less, averaging .31 hours per week, which we later learned was influenced by directions from her supervisors to focus first on raising the reading performance of the special needs students she teaches full-time. Other variations across teachers have no obvious explanation. For example, "Heather," a fourth grade teacher, provides 2.58 hours of science instruction per week, compared to 1.77 hours per week of science offered by "Melissa," a fifth grade teacher just down the hall. Sizable standard deviations indicate large swings in several teachers' science scheduling. The case of "Christina," a full-time technology teacher who often integrates science into upper elementary technology classes, illustrates this within-teacher variation. Christina provided science experiences for each of her classes an impressive 3.57 hours per week. Yet the associated standard deviation of 2.54 hours per week makes it clear that time available for science in her classroom fluctuated greatly.

Table 6
Average Weekly Science Teaching Time in Hours Based on Eight Weeks of Reporting Using the WTS

Hours	Sarah	Melissa	Christina	Heather	Angela	Jessica	Tiffany	Rebecca	Michelle	Kimberly
M	0.81	1.77	3.57	2.58	1.42	0.63	1.07	2.29	1.74	0.31
SD	0.14	0.73	2.54	0.66	1.26	0.37	0.88	0.27	0.7	0.04

In addition, the WTS allowed us to see the considerable variation in the length of the teachers' science lessons more clearly, as well as the many days when no science was taught. Table 7 shows that no science was taught on 183 days, which comprised 45.7% of the 400 instructional days reported on in the eighty weekly surveys the teachers completed. When science was taught, the most prevalent lesson length was 21-30 minutes, accounting for sixty-one lessons, or 28.0% of the 217 lessons reported. It is instructionally significant that the actual reported values for seventy-two lessons, 33.2% of those taught, fell between 5-20 minutes. Combining these with the lessons in the popular 21-30 minute range, we find that 133 lessons out of 217 taught (61.3%) lasted 5-30 minutes, somewhat below the expected outcome given the 30-40 minute average lesson length that six out of ten teachers in our sample selected on the SEC®.

Table 7
Number of Minutes of Science Instruction per Day—WTS (*n* =80 weekly reports)

Minutes	Monday	Tuesday	Wednesday	Thursday	Friday	Total
None	34	26	41	25	57	183
1 to 10	7	5	5	7	4	28
11 to 20	8	14	7	8	7	44
21 to 30	8	15	12	20	6	61
31 to 40	3	0	0	1	0	4
41 to 50	12	16	8	15	4	55
51 to 60	1	1	1	0	1	4
61 to 90	5	1	4	1	0	11
91 to 245	2	2	2	3	1	10

To summarize, the WTS results regarding time the teachers were able to devote to science instruction showed that the teachers spent on average 1.64 hours per week on science, well below the 1.9 hours per week they reported soon thereafter on the SEC®. Using the thirteen to fourteen weeks per year for science selected most frequently on the SEC®, we can estimate roughly 21.2-39.4 hours of science instruction per year, per teacher. Two patterns that stand out in the WTS data are the great variation in time allotted for science across teachers, and from week to week for individual instructors. Equally evident is that no science is taught on many school days, true for 45.7% of the 400 days for which we collected WTS data. Finally, 61.3% of the lessons lasted 30 minutes or less, well below the 30-40 minute range we expected based upon our teachers' SEC® responses.

The Scoop Notebooks prepared by eastern cohort BSSP teachers in Spring 2008 provide a window into the lesson length the teachers aim for when asked to provide a sample of their science teaching practice for sharing with their peers, the project staff, and evaluators. Each Notebook provided documentation for three to five science lessons, focused on a single topic, and taught during Spring 2008. Each teacher was observed by a BSSP staff member at least once during the Scoop lesson series, and received written comments from staff on the Notebook contents. In addition, the Notebooks were shared with peers in a poster session format, and a photocopy of each Notebook was sent to the project evaluators. Although the teachers were encouraged to choose lessons that were "typical" of their science teaching, it seems likely that they selected for public display lessons they considered exemplary, even more so since student work samples produced during these lessons were required in the Notebooks. Table 8 shows the length of thirty Scoop lessons planned by seven of the teachers in our sample who completed a calendar for the Notebook. Whereas 61.5% of the lessons recorded for the WTS lasted 30 minutes or less, the teachers expected 63.3% of the lessons for the Scoop to exceed 30 minutes. The Scoop calendars provided a window into teachers' perceptions of the optimal lesson length for their students when the teachers prepared to share their practice and the usual constraints are temporarily lifted.

Table 8
Length in Minutes of Science Lessons Reported in Scoop Notebook Calendars

	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5
Heather	45	45	45	120	--
Christina	50	50	50	50	50
Melissa	50	45	45	60	--
Angela	25	30	45	60	45
Sarah	30	30	30	30	30
Michelle	80	80	60	--	--
Jessica	25	20	30	20	--

* n=10, missing data for three teachers.

The BSSP staff conducted a science lesson observation for each of the ten teachers in this study during Spring 2008 using the *Classroom Observation Protocol* [29]. The observations were scheduled to coincide with each teacher's Scoop lessons. The lessons observed ranged from 10 minutes to one hour long, with half of the lessons lasting under 30 minutes. This suggests that teachers' ability to carve out time for longer science lessons fell slightly short of the intentions shown in their Scoop Notebooks.

A portion of the interview conducted with each teacher in June 2008 addressed the time the teacher was able to devote to science teaching. In general, teachers' statements during the interviews were consistent with the information provided on the WTS. For example, the estimates given during interviews by Jessica, Tiffany, and Melissa for the minutes per week devoted to science were almost identical to the averages computed from their weekly surveys. However, in "Angela's" interview, she stated that in her school, "we're maybe allowed one hour a week to teach science," but this is lower than the 1 hour 25 minute average we calculated based on the eight weekly surveys she submitted. Apparently, she was teaching more science than her school's policy allowed. Although interview data can be used to gauge the accuracy of other sources, we believe the WTS reports to be most reliable concerning time devoted to science.

In addition to investigating the amount of time elementary teachers in the BSSP devoted to science instruction and how it was distributed, we also wanted to know what influenced teachers' decisions about the level and use of science teaching time. Our primary data source for addressing this question was a cluster of six items on the WTS regarding influences on what and how science is taught. We adapted these from a longer series in the SEC® pertaining to influences on the content of science instruction. On the WTS, the teachers were asked to "Reflect back on your science teaching this week," when responding to each item. The influences included the following: those of parents or community; State or district curriculum frameworks, standards, tests or results; and, the textbook or curriculum materials selected by the district. As shown in Table 9, the teachers in our sample generally viewed these factors as having an influence midway between "little or no influence" (3.0) and a "somewhat positive influence" (4.0). The influences of State and district curriculum frameworks and standards, as well as State tests were rated as slightly greater than those of district-level tests and parents or community. The responses were quite consistent across teachers, with means ranging from 3.50 to 3.78 for nine teachers, and an even more positive average response of 4.36 for the tenth teacher.

Table 9
Influences on What and How Science Is Taught—WTS (*n* =80 weekly surveys)

1 = Strongly negative; 2 = Somewhat negative; 3 = Little or no influence;
4 = Somewhat positive; 5 = Strongly positive.

Weekly Teaching Survey Item	All (*M*)	All (*SD*)	Strongly negative	Somewhat negative	Little or no influence	Somewhat positive	Strongly positive
19. The parents or community influence what and how I teach.	3.44	0.42	1	0	46	29	4
20. State tests or results influence what and how I teach.	3.69	0.27	0	0	21	56	3
21. State curriculum framework or standards influence what and how I teach.	3.79	0.32	0	0	21	55	4
22. District curriculum framework or standards influence what and how I teach.	3.72	0.37	0	0	27	49	4
23. The textbook and/or curriculum materials selected by the district influence what and how I teach.	3.64	0.48	1	0	32	40	7
24. District-level tests or results influence what and how I teach.	3.47	0.36	1	0	43	33	3
Total ratings (out of 480) regarding degree of influence			3 (<1%)	0	190 (39.6%)	262 (54.6%)	25 (5.1%)

Interestingly, just three responses regarding influences on instruction were lower than "neutral or no influence" (3.0) on any of the eighty weekly surveys gathered. In other words, on seventy-seven of the eighty weekly surveys, the teachers rated as neutral to somewhat or strongly positive the influences of district and State standards and tests, and textbooks and other materials provided by the district, and parents and community. The positive nature of the teachers' responses was expected in some respects, and unexpected in others. For example, the teachers became very familiar with the State of Montana science education standards through the Big Sky Science Partnership activities, which may have affected their generally favorable view of the influence of standards, and even testing, on the previous week's science instruction. Concomitantly, several formerly low performing districts had recently witnessed a fairly dramatic rise in their students' performance on State reading tests, a circumstance their teachers spoke of with pride and which may have produced a generally favorable view of standards and testing. However, we observed ample justification for lower ratings for some items; for example, item 23 where there was a lack of current textbooks or resources of any kind for science in several of the districts. This raises the question of how to determine the quality and influence of resources and support structures for elementary science if teachers are too accustomed to scarcity to name these as potential influences.

In addition to the Likert-style items regarding influences on science teaching, the WTS included an open-ended question that allowed the teachers to write a brief statement regarding one or more factors that had the greatest influence on their science instruction during the previous week. This question was left blank in seventeen of the eighty weekly surveys completed by BSSP teachers. Twenty of the remaining sixty-three statements pertained to reading, and typical responses included Jessica's comment that, "Everything is correlated with our reading materials"; or, "Rebecca's" that "Science this week focused on reading vocabulary." Thirteen responses noted the influence of the BSSP on science instruction in the previous week. Examples included the following responses:

- "Because of the lack of resources, I used what I learned in the BSSP courses to develop this unit." (Rebecca)

- "The BSSP class has had a great influence on what I am teaching in science this year. I have used a lot of materials from books that I was given by them. They have been a great help." (Melissa)

- "We also created concept maps on what students know about rocks. This is going to be our next unit because it is of interest to the students, it's in the science curriculum, and I am working with this in BSSP classes." (Angela)

Six statements, including the following examples, referred to the influence of students' prior knowledge and teachers' efforts to take into account students' knowledge and interests when planning for instruction.

- "I try really hard to bring in what students already know about rocks in this area by what they observe. Then, I moved them into how those are used in everyday things that they don't know about." (Sarah)

- "What students know and what they wondered about will help to design lessons for the fossils unit. I found that some of the questions they asked were the same questions I came up with when developing the unit." (Rebecca)

Culture was cited in six of the eighty weekly surveys as influencing the week's science instruction, and examples like the following ones were given:

- "Our culture teacher [provided] community resources for us to determine which frogs reside in our area." (Tiffany)

- "The cultural element was present when we discussed rocks that made good arrowheads." (Kimberly)

The remaining influences on the previous week's science teaching included the following: State testing, which inadvertently overlapped with administration of the weekly surveys in several respondent's districts (8); the district curriculum (4); miscellaneous scheduling constraints (3); State standards (1); parental support for science (1); and, suggestions from other staff members regarding the teacher's science program (1). Lack of time for science surfaced relatively often in conjunction with the other themes above. Each teacher made at least one specific reference in the WTS to the lack of adequate time for science due to district scheduling and curriculum requirements, especially regarding reading. However, there was no single culprit responsible for the observed outcome that time for science was often minimal or unpredictable. As "Michelle" explained, "Science is the first subject to go whenever our schedule gets interrupted."

During individual interviews conducted in June 2008, the teachers once again responded to questions regarding influences on their science teaching. School scheduling requirements surfaced frequently in the teachers' responses.

- "Well, the school does get in the way of it [science] a little bit because we have so little time. Seems like if I teach it at all, I have to grab time from here or there or someplace. And like I said, we just don't have a lot time for it, so that influences it quite a bit…A lot of the time, I end up doing something just out of the book because I've got fifteen, twenty, thirty minutes and you really can't set up for anything hands-on in that amount of time." (Melissa)

- "We have a very limited time schedule. So we're maybe allowed an hour a week to teach science. I'm free to do whatever I want in that time. And I can kind of integrate it wherever I want as long as I am still teaching the math and reading. That's the most important at our school." (Angela)

- "Well, scheduling. We had…little time [for science] each week and then we have to follow our district benchmarks." (Sarah)

Many teachers commented during interviews on their schools' strong focus on reading/language arts and mathematics which they attributed to district, State, or national policies. Teachers did not negate the importance to their students of strong skills in reading/language arts and mathematics. However, they wondered aloud where the additional instructional time would come from now that fourth graders in Montana were being tested in science, and the results would be made public for the first time in Fall 2004. According to one teacher, even parents' attention was being channeled toward a focus on reading. Tiffany stated, "My parents are wonderful, but since the push was reading…basically what they got from the school was how the child was doing in the reading department."

Although no direct questions were posed about the influence of the BSSP on science instruction, the majority of teachers referred to the Partnership's positive influence on their science teaching during the interviews. They frequently commented on the lessons and resources provided by the project as enabling them to teach science more often than before, or moving their practice toward more hands-on and/or inquiry-focused approaches. To summarize, the interviews indicated that the time devoted to science teaching by BSSP teachers was influenced by time constraints that were often beyond the teachers' control, especially the squeeze imposed by the current emphasis in their districts on reading/language arts and mathematics. As in their WTS responses, they also cited their students' prior knowledge and interests, their own efforts to incorporate in science the culture of the American Indian communities where the schools were located, parental involvement, teacher colleagues, and the BSSP as influencing how much science was taught, and the science content and pedagogy implemented. However, these latter factors appeared to take effect within a diminished sphere, influencing only time that was not already off limits due to school and district mandates reserving a specific number of hours, often at a prescribed time of day, for reading/language arts and mathematics. At times during the interviews, it appeared that fitting science into the instructional day was not just variable, but covert.

Conclusions and Implications

We initiated this study to better understand why elementary teachers who were actively engaged in face-to-face and on-line activities of the Big Sky Science Partnership (BSSP), many of whom had voluntarily ramped up their involvement by entering an MS in Science Education degree program, nonetheless reported that their opportunities to teach science were quite limited. We set out to learn how much time BSSP teachers devoted to science teaching, what influenced their decisions, and how this might affect the Partnership's ability to be an agent for positive change in school science programs in our region. To accomplish this, we used data already being collected by the Partnership evaluation, including the annual Surveys of Enacted Curriculum® (SEC®), classroom observations using the *COP*, and the Scoop Notebook created by the teachers to document a science unit or lesson series. We also implemented a Weekly Teaching Survey (WTS) designed for this study, as well as individual teacher interviews to follow up on issues raised in the earlier phases of data collection. Our teacher sample included ten, grades 1-5 teachers representing the fourteen instructors in the BSSP eastern cohort. Their experience ranged from four years to more than twenty years in the field, and they taught in seven different schools.

We learned that the anecdotal reports we had received from BSSP teachers regarding the relatively limited amount of time they teach science were generally true. The results of the SEC® that the teachers completed in June 2007 and 2008 provided the "best case scenario" in one sense. The BSSP teachers' responses on the *SASS* indicated on average that they taught science 1.8-1.9 hours per week, not too far below findings in large-scale studies like the *Schools and Staffing Survey* (*SASS*) and the *National Survey of Science and Mathematics Education* (*NSSME*). The *SASS* and *NSSME*, like our study, included both primary and upper-level elementary school teachers, and their respondents reported teaching science for 2.04 to 2.1 hours per week, just slightly above the average for our teachers. However, the BSSP teachers' responses to an SEC® item regarding weeks per year spent teaching science provided a reality check regarding the amount of science instruction they were able to fit into a typical school year. The majority of the teachers reported teaching science for 13-24 weeks per year, a handful responded 1-12 weeks, and none chose the higher option of 26-36 weeks. Based on these results, our best case scenario was looking less positive. How could we assist elementary teachers to adequately address our State's comprehensive and challenging science standards when even the most active were able to teach science for only 60% of the forty-week school year, and then only for a limited number of hours per week?

Our efforts to learn more about the time BSSP teachers were able to carve out for science via the Weekly Teaching Survey (WTS) provided insights into the considerable variation among the teachers, and the improbability of developing a one-size-fits-all solution to the low profile—even invisibility—of science in some classrooms. We learned through the WTS that although the teachers taught science on average for 1.64 hours per week during the eight instructional weeks we monitored with the WTS, there were wide variations across instructors, and across weeks for individual instructors. Even more tellingly, no science was taught on 45.7% of the teaching days reported. Teachers' comments during interviews built a picture of a "catch as catch can" science curriculum. This circumstance often appeared to be the unintentional result of district adoption of highly structured, time-intensive curricula to raise student performance in targeted subject areas, especially reading/language arts and, secondarily, mathematics. In these priority areas, teachers reported that their schools' expectations were clear regarding when to teach and for how long, the materials to be used, and student performance criteria equated with success. In coming out strongly for high priority subject areas, the districts appeared to be inadvertently working against learning opportunities in sidelined subjects. The result was clear in the highly variable scheduling of time for science.

The WTS results also revealed the brevity of the majority of science lessons taught, bringing into question at what point lesson duration affects the coherence and quality of the curriculum. Teachers' WTS reports showed that on one-third of the days when science was taught, the lessons lasted 20 minutes or less, and 27.9% of the lessons lasted 21-30 minutes. These were substantially shorter than the 30-40 minute estimate for a "typical" science lesson reported by the teachers when responding to the end-of-year SEC®. In contrast, the science lessons teachers planned when sharing their practice with BSSP colleagues lasted more than 30 minutes over 60% of the time, indicating these experienced teachers' sense of the time necessary for model science lessons. We hesitate to state where the divide lies between lessons that are too short to advance students' science learning, and lessons providing enough time for genuine learning to occur. Yet common sense tells us that predictable instructional time of moderate length is needed to meet national, state, and district science standards that place an emphasis on inquiry, on challenging content rolled out gradually through coherent learning progressions, and on making connections to students' lives. Science programs heavily weighted toward short teaching segments offered on an ad hoc schedule seem destined to fail.

On the WTS, the teachers were also asked to report on major influences on their science instruction for the previous week. Their responses showed that district and State standards, curriculum, testing, textbooks and other teaching materials provided by the district, and parents or community were all fairly influential. During interviews, the teachers sometimes chafed against restrictions on their teaching, particularly what they saw as a disproportionate focus on reading/language arts stemming from their districts' State test results. Yet when given the opportunity on the WTS to voice misgivings about the influence of State assessments, they did not. Indeed, the teachers assigned almost every factor influencing their science instruction, including testing, as having a "somewhat positive" effect. During interviews, the teachers also frequently cited the positive effect of BSSP on their science instruction, primarily through providing them with teaching resources, a repertoire of strategies, and increased confidence in their content knowledge.

In the BSSP, we are moving forward with the knowledge that the time Partnership teachers have available for science teaching is significantly less than anticipated. Also, it appears that teachers' opportunities to teach the State standards-based science content provided in the professional development and master's degree experiences offered by the project will remain restricted in the short term. We also know that the tightly prescribed curricula many districts in our region have adopted, especially in reading/language arts and to a lesser extent in mathematics, leave little room for integration of science across the curriculum. In response, we are pursuing several options. First, we are continuing to gather data through periodic administrations of the WTS regarding teachers' patterns of science instruction. We are also making use of an assessment developed by the BSSP evaluation staff that documents not only participants' opportunities to learn science content through the project, but also opportunities to teach the content. This enables us to tailor professional development to instructional segments that are real, rather than to an unattainable ideal that assumes far more time for elementary science than is actually available. Secondly, as we recruit the Partnership's second cohort of elementary teachers, we are meeting with school administrator/teacher pairs to work out a mutually agreeable schedule of science instruction given the unique context in each school. The original memoranda of agreement with partner schools now seem too generic. Updated versions will include specific information on instructional time for elementary science. We will also do everything feasible to enable BSSP teachers to do more with the time available for science, and to avoid a "less is less" outcome for their students. Classroom observations of BSSP teachers using the *COP* show that the quality of instruction in BSSP teachers' classrooms is relatively high compared to that of national counterparts in the areas of collaborative/cooperative learning, connecting science to students' lives, and some aspects of science inquiry [32]. In addition, WTS results show that teachers were able to connect the previous week's science instruction to contemporary and historical tribal and community issues more than 40% of the time. These are some of the strengths upon which the Partnership can and will continue to build.

Finally, we will attempt to extend our Partnership's influence by sharing knowledge in the policy arena. As illustrated with NAEP data shared earlier in this paper, time on task in science has a demonstrable connection to student performance. Our State, like many others, has developed truly visionary K-12 science standards, yet has not established a holistic vision for balancing learning opportunities across subject areas in elementary classrooms. The result is purposeful, intentional instruction in certain subject areas, and an almost accidental curriculum in others. Our Partnership is going on record here as opposing elementary science as an accidental curriculum.

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