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The Influence of Contextual Factors on the Sustainability of Professional Development Outcomes

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Abstract This study investigated how contextual factors influenced the sustainability of outcomes from a 3-year, state-funded professional development program that provided science assistance for K-2 teachers in small, rural school districts. The research used a case-study approach with a purposive sample of five elementary schools that varied in instructional time in science several years after the funding period. The primary data sources were teacher surveys and interviews conducted 2 and 3 years after the end of the professional development program. The findings highlight variations across schools and the influence of principal support, resources, collegial support, personal commitment, and external factors. The research holds practical implications for enhancing long-term sustainability of professional development outcomes in science education.

Keywords Teacher professional development · Science education · Elementary education · Context · Administrative support · Collegial support

Introduction

Elementary school science is increasingly seen as providing a critical foundation for students' future interest and proficiency in science. Early experiences in science help students develop problem-solving skills needed to function productively in a

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scientific and technological world (National Research Council, 2005, 2011). The Next Generation Science Standards (NGSS) aim to enrich science instruction by increasing active learning. Rather than a focus on fact memorization, NGSS calls for inquiry-based and problem-solving experiences that demonstrate science applications in the real world (NGSS Lead States, 2013). The expectation is that students will "engage in the practices and not merely learn about them secondhand" because they cannot "comprehend scientific practices, nor fully appreciate the nature of scientific knowledge itself, without directly experiencing those practices for themselves" (p. 2). The National Science Teachers Association (NSTA, 2002) suggests that inquiry-based science—where students learn how to ask appropriate questions that can be answered through scientific inquiry, to design and conduct investigations, to analyze and interpret data, and to draw conclusions—should be a basic part of the curriculum every day for elementary students at all grade levels. In their position statement, the NSTA states that, in an inquiry approach, "Children interact with their environment, ask questions, and see ways to answer those questions. Understanding science content is significantly enhanced when ideas are anchored to inquiry experiences" (2004, p. 1).

In contrast to these recommendations, science is not a central component of daily instruction in elementary schools (Banilower et al., 2013; Dorph, Shields, Tiffany-Morales, Hartry, & McCaffrey, 2011; McMurrer, 2008; Olson & Labov, 2009). Since the No Child Left Behind legislation, the time spent on science instruction has decreased as administrators faced accountability measures and devoted more time and resources to mathematics and English language arts (Griffeth & Scharmann, 2008; Marx & Harris, 2006; McMurrer, 2008). Moreover, when teaching science, elementary teachers tend not to emphasize inquiry skills or engage students in scientific practices; researchers report that only 10 % of California elementary students receive science instruction through inquiry methods (Dorph et al., 2011). Yet discovery based, active learning in science is more effective than teacher-led learning for elementary students (Zimmerman, 2007). Investigative and inquiry-based activities help students develop a deeper understanding of science concepts (National Research Council, 2005, 2011; National Science Teachers Association, 2004; Supovitz & Turner, 2000). Beyond conceptual understanding, science instruction should develop students' ability to assess the status of knowledge claims, to understand investigative methods and measurement tools, and to communicate and represent ideas (Duschl, 2008). Some researchers contend that understanding how knowledge is generated in science is as important, or perhaps more important, than the concepts themselves (Symington & Tytler, 2004).

Teacher participation in effective professional development offers a promising approach to improving science instruction (Basista & Matthews, 2002; Heck, Rosenberg, & Crawford, 2006; Supovitz & Turner, 2000). However, for ongoing student learning, teachers must continue to teach science regularly and to use the strategies learned in professional development. The majority of studies examine short-term rather than long-term outcomes of professional development. This study addresses the need for longitudinal research by investigating how contextual factors influenced the sustainability of professional development outcomes beyond the funding period. Earlier research on the impact of a 3-year, state-funded professional development program designed to improve K-2 science education showed significant changes at the program's end but a beginning pattern of decline in outcomes 2 years after the funding ended (Sandholtz, Ringstaff, & Matlen, in press). This follow-up study examined differences in contextual factors across schools and their influence on teachers' decisions about science instruction. The primary research question was: How do contextual factors support or hinder science education after professional development ends?

Conceptual Framework

Researchers report that professional development has the capacity to build teachers' content and pedagogical knowledge and thereby promote changes in classroom instruction (Darling-Hammond & Sykes, 1999; National Staff Development Council, 2001; Sparks, 2002; Stigler & Hiebert, 1999). Desimone (2009) proposes an operational theory of how professional development influences teachers, their instructional practice, and student learning. The four steps in the theory include: (a) Teachers participate in effective professional development; (b) their participation increases their knowledge/skills or changes in attitudes/beliefs; (c) teachers adapt their instructional practices; and (d) changes in instructional practices promote student learning. In this model, context functions as a key mediating influence.

Contextual factors and organizational support play a critical role in the extent to which teachers implement and sustain new classroom practices (Guskey & Sparks, 2002; National Academy of Sciences, 2015). Changes in teaching practice are influenced by both teacher-level factors, such as attitudes and skills, and school-level factors, such as administrative support (Guskey, 2002; Mumtaz, 2000). Researchers report a relationship between contextual factors beyond the teachers' control and lack of change in science teaching practices following professional development (Johnson, Monk, & Swain, 2000). Adoption of teaching innovations depends on not only individual teachers' perceptions of the value of the instructional practice, but also their perceptions of school and district support for the innovation (Sherry, 2002). In a study of elementary teachers, high-quality science lessons are correlated with teachers' high self-efficacy in combination with positive beliefs about contextual support (Haney, Lumpe, Czeriak, & Egan, 2002).

Key contextual factors that influence changes in teachers' classroom practices after professional development include administrative support, collegial support, and resources. Elementary teachers who perceive their principal as supportive have higher confidence and beliefs in their own abilities to promote student learning (Hoy & Woolfolk, 1993). Data from 42 projects involved in the Local Systemic Change program indicated that principal support predicted both instructional time in science and teachers' use of investigative strategies (Banilower, Heck, & Weiss, 2007). Guskey and Sparks (2002) reported that professional development programs that lacked administrative support did not show positive changes in teachers' practices or improved student learning. Administrative support is particularly important in promoting teachers' continued use of reform-based strategies (National Academy of Sciences, 2015; Steele, 2001).

Collegial support and teacher collaboration also contribute to teachers' use of strategies learned in professional development. Appleton and Kindt (1999) found that, for novice elementary teachers, support from colleagues played a role in both their self-efficacy in teaching science and their classroom teaching practices. A follow-up study of professional development in mathematics similarly reported that collaboration with other teachers, as well as ongoing commitment from the professional development team, supported changes in teaching practice (Franke, Carpenter, Levi, & Fennema, 2001). Depending on who participates and engages in professional development, teachers may encounter differing levels of collegial support and opportunities for collaboration in their schools and districts. In addition, collegial support and collaboration experienced during professional development may not extend beyond the program.

Available resources for teachers affect both initial implementation and ongoing use of reform-based teaching strategies. Researchers report that the availability of resources in combination with content knowledge influences the quality of elementary teachers' science lessons (Sullivan-Watts, Nowicki, Shim, & Young, 2013). To implement investigative science lessons, teachers benefit from concrete tools, lesson ideas, and classroom resources (Wyner, 2013). School-mandated curricula tend to hinder implementation of reform-based strategies, whereas science kits, materials for experiments, and teacher reference materials promote their use (Appleton & Kindt, 1999; Steele, 2001; Sullivan-Watts et al., 2013).

Guided by the operational theory of how professional development influences teachers and their instructional practices, this study specifically examines how context acts as a key mediating influence. Whereas earlier research related to this project examined changes in teachers' content knowledge, self-efficacy, instructional time, and instructional practices in science, this follow-up study focuses on the way in which contextual factors affect the longevity of science instruction and strategies.

Methods

This study is part of a larger longitudinal research project examining the sustainability of professional development outcomes. The research project focuses on K-2 teachers who completed a 3-year professional development program that provided science assistance for teachers in rural districts. The program included three main components: (a) intensive adult-level science content instruction; (b) pedagogical training focused on science instruction and how to connect science to language arts and mathematics; and (c) training and support to facilitate teacher collaboration. The content and pedagogical instruction took place during summer institutes, regional meetings, and school site sessions that provided teachers with over 100 contact hours. The content instruction focused on a different branch of science each year (physical, earth, and life sciences) and was based on topics included in the California state science standards. The program incorporated adult-level science instruction with research-based instructional strategies. Teachers learned science content through pedagogical approaches that they could subsequently use in their classrooms. Instructors modeled the use of scientific inquiry and helped teachers develop inquiry-based science units and integrate science with mathematics and language arts instruction. To enhance collaboration, the program created opportunities for teachers to work together during summer institutes and regional meetings during the academic year. It also hosted a website for teachers to communicate, share lesson plans, and access resources. Neither author was involved in designing or providing the program.

The 3-year program included 39 teachers from 16 schools in 16 districts in northern California. Half of the districts were one-school districts in which a particular grade level may have only one teacher. Student enrollment prior to the program ranged from 148 to 5087, and the poverty level ranged from 11 to 30 % of families. Student performance on standardized tests indicated low academic achievement. Due to changes in teaching assignments, relocations, death, and attrition, there were 34 participating teachers by the end of the 3-year program. Our longitudinal follow-up research project includes 30 of those teachers, representing 14 schools and 13 districts.

In this study, we used a comparative case-study approach with a purposive sample of five schools. A case-study design is particularly well suited to examining how and why contemporary events occur (Yin, 2003). Since the aim was to investigate how contextual factors influenced the sustainability of science instruction after professional development, the school was the unit of analysis. To examine critical cases which had "strategic importance in relation to the general problem" (Flyvberg, 2001, p. 78), we selected schools that represented a range in participating teachers' instructional time in science. Comparative cases facilitate examination of factors that may mediate teachers' professional practice but may not be evident with single cases or cases that do not differ in ways important to the general problem (Patton, 2002). We used survey data from the larger research project to determine median instructional time in science during the second and third academic years after the program ended. The case-study schools included two with low instructional time and minimal change, two with significant decreases in instructional time, and one with high instructional time (see Fig. 1). Three teachers in each school had completed the professional development. Table 1 summarizes demographic information.

The primary data source for the case studies was interviews conducted with the teachers during the second and third academic years after the professional development ended. As part of the larger project, the interviews focused on instructional time in science, confidence in teaching science, content knowledge in science, instructional and curricular choices, integration of science instruction into other subjects, and support and resources for teaching science. The questions probed for changes during the time after the professional development ended and reasons for any reported changes. Researchers conducted interviews in person or via telephone. Each interview lasted approximately 1 h and was audio-recorded and subsequently transcribed.

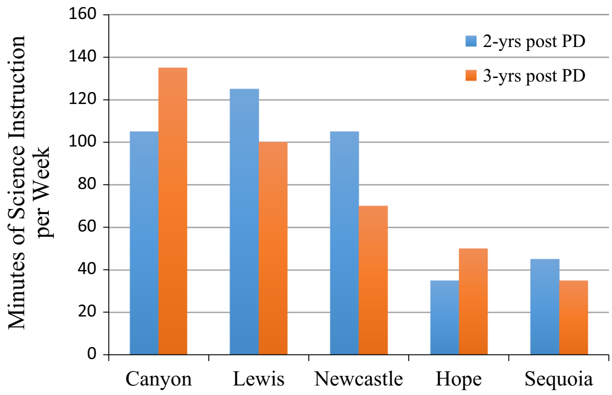

Fig. 1 Median teaching time by school

Analysis of interview data followed qualitative research procedures such as coding and data displays (Bogdan & Biklin, 1998). All verbatim interview transcriptions were compiled in an electronic database and coded using the Dedoose software program. The program provided a system of data management and a means of retrieving, sorting, and organizing the interview excerpts. The software program allowed researchers to search across the database for specific codes or combination of codes. All of the excerpts with the specific codes could be pulled up and reviewed by the researchers. The system provided various options such as charts, graphs, and plots for displaying the data. However, since the focus of data analysis for this study was explanation building, researchers primarily used the system to retrieve and organize interview excerpts which they then could examine and analyze to determine how school contexts affected teachers' decisions.

The transcriptions were coded according to a system of a priori codes generated from the conceptual framework and the protocol for teacher interviews. During the coding process, emergent subcategories were added. A chart of the coding categories and subcategories is included in the "Appendix." The software allowed for multiple codes to be assigned to interview excerpts, which aided in searching for and retrieving data across categories. For example, teachers' descriptions of science instruction in their classrooms may have included information related to multiple codes such as "strategies used," "scaffolded-guided inquiry," "changes in strategies," and "factors influencing strategies." The code "lack of" could be assigned as a double code to any of the categories. To establish reliability in coding, we used a system of multiple coders for each transcript. All coders received training in the coding system and demonstrated competence in applying the codes on a sample transcript. Two coders then independently coded each interview transcript. Any discrepancies between the two were noted, discussed, and resolved. A third coder subsequently reviewed all coded transcripts for consistency with the system.

For this study, we searched the database, retrieved interviews excerpts, and created data displays for each case-study school. Data analysis focused on explanation building (Yin, 2003), specifically on understanding how contextual factors influenced

Table 1 Demographics of case-study schools

School	#Students	%Free-reduced lunch	Student ethnicity	Title I	%ELL
Canyon	588	54	1 % African American	Yes	N/A
			1 % Asian		
			12 % Hispanic		
			3 % Native American		
			77 % White		
Lewis	457	63	1 % African American	Yes	51.7
			1 % Asian		
			60 % Hispanic		
			1 % Native American		
			37 % White		
Newcastle	224	92	3 % African American	Yes	59.9
			0 % Asian		
			88 % Hispanic		
			0 % Native American		
			7 % White		
Hope	515	N/A	24 % African American	Yes	39.4
			14 % Asian		
			36 % Hispanic		
			2 % Native American		
			12 % White		
Sequoia	455	73	5 % African American	Yes	10.3
			3 % Asian		
			45 % Hispanic		
			1 % Native American		
			41 % White		

Pseudonyms

teachers' decisions about science instruction. We initially retrieved, organized, and examined data for each school related to four key contextual factors identified in our earlier studies as supporting and impeding science instruction: administrative support, resources, curricular demands, and collegial support (Sandholtz & Ringstaff, 2011, 2013; Sandholtz et al., in press). We subsequently looked for explanations about how these factors affected the choices teachers made about how much time to spend teaching science and what instructional strategies to use. In constructing each school case, we focused on the four key contextual factors as well as emerging factors for that site. For example, at some schools, state designation as a program improvement site emerged as an important influence. In analyzing the impact of these factors, we examined teachers' interview responses and sought to ascertain their rationale for their decisions about science instruction after the professional development ended. After completing the case for each school, we conducted a cross-case analysis. In this phase, we first examined similarities and differences across schools. We then focused on identifying patterns across schools that would explain the ways in which contextual factors affected teachers' decisions over time. Our aim was to understand, from the teachers' perspectives, the differences in school contexts and their specific impact on teachers' decisions about instructional time and strategies in science. The small sample of teachers combined with the small, rural school settings may limit the generalizability of the findings to other populations of teachers, but the trends in the data may suggest focal areas for longitudinal studies in other settings.

Results

Contextual factors varied across schools and influenced the sustainability of science instruction after the professional development ended. In the following sections, we summarize findings for each of the five case-study schools, which have been assigned pseudonyms. The schools are grouped into three categories of instructional time in science: low instructional time with minimal change, significant decrease in instructional time, and high instructional time. Following the descriptions for each school, we discuss cross-case patterns.

Low Instructional Time with Minimal Change

Sequoia Elementary School

Sequoia Elementary is a small school with fewer than 500 students. The diverse student population includes approximately 10 % English language learners, and 73 % of students qualify for free or reduced lunch. At Sequoia Elementary, the median instructional time decreased slightly from 45 min per week to 35 min per week during the second and third years after the professional development ended. In interviews, participating teachers identified similar factors as influencing their science instruction: a focus on mathematics and language arts, limited support and resources, and a lack of collaboration. With the advent of the Common Core standards, each teacher pointed out a renewed emphasis on mathematics and language arts. As one teacher phrased it, "To be honest with you, with the Common Core coming, they are just shoving Common Core, English language arts, and math down us. That's where their focus is." A second-grade teacher described a strict pacing guide that made it challenging to teach science: "I have to squeeze science in when there is not a block of time mandated because our pacing guide is just reading and math. When I say reading, I mean all of language arts." The teachers also identified state testing as increasing the focus on mathematics and language arts and lessening available support for science.

Some variations in expectations resulted from changes in administrators at the district and school levels. During a 6-year time period, three different principals were assigned to Sequoia Elementary. Teachers perceived each principal as not restrictive about teaching science but also not supportive in terms of providing supplies, additional professional development, or time for collaboration. When asked about support and resources for teaching science, one teacher replied, "Zero. Unless you want to call a textbook and a workbook support." Another teacher made a similar statement, "There aren't any. Everything I do, I go out and make my own, buy on my own, collect on my own." Because the school has "very few science supplies," another teacher resorted to asking for donations from donors to secure supplies for hands-on science activities.

Sequoia teachers also missed the collaboration that the professional development program incorporated. "Seeing how other people do it" and sharing strategies among teachers had bolstered their science teaching. Due to changes in teaching assignments, the teachers had no one else in their grade-level teams who had participated in the professional development. Without summer institutes or regional meetings through the program, they primarily worked on science individually. One teacher commented that collaboration time at the school was focused on "anything having to do with the state tests."

The main reason that the Sequoia teachers continued to teach science at all was because they could "see value in it." Teachers pointed to benefits for students and their personal initiative to teach science. For one Sequoia teacher who said she was "still excited about teaching science," instructional time in science actually increased in the third year after the program. In her case, a change in teaching assignment from second grade to sixth grade facilitated more instructional time. In addition to her personal interest in teaching science, she found it easier to include science in the curriculum because "the school day is longer" in sixth grade and because the students are "more able to focus and be engaged" in science activities.

When asked about the types of support that they most needed, Sequoia teachers identified time, supplies, and additional professional development. Beyond time for science instruction, teachers wanted "more time to collaborate with other teachers for science" instead of other subjects. They pointed to a need for supplies to use in experiments and other hands-on activities. Rather than intensive professional development, the teachers suggested a few follow-up sessions each year. As one teacher stated, "It doesn't have to be a lot, maybe a couple of days in the summer or maybe a couple of days throughout the year."

Hope Elementary School

Hope Elementary has a student population of just over 500 students, including approximately 36 % Hispanic and 24 % African American students. Approximately 40 % of the students are English language learners. At Hope Elementary, the participating teachers' median instructional time in science increased slightly from 35 min per week to 50 min per week during the second and third years after the professional development ended. In interviews, the Hope teachers noted how changes in administrators at the district and school levels influenced science instruction. For example, the curriculum director "who really wanted science at the lower grades in elementary schools" moved to a different city, and a new superintendent emphasized other subjects. Frequent changes of the school principal directly affected instructional time in science. They described constantly having to adjust to meet "the expectations of a new principal" who may require "sticking to a pacing calendar and making sure that the students were getting ready for the state tests" or alternately who may be more open "to experimenting and incorporating more science and social studies." The principal at the time the professional development began was supportive of their participation, but when the program ended a different principal had been hired. As one teacher stated, "It was very difficult for me to come out of the program when I was so excited about the things we were learning but then we had the testing and the pacing" which she felt constrained her science teaching. She explained,

> I did not feel confident enough to experiment… and it didn't seem like she [the principal] was open to that kind of thing happening in the classroom. It was like your objective was one thing and it had to be that at the end of the lesson. That's not the way things were when kids were experimenting in science.

Another teacher proposed that the principal thought "teaching science is fine" as long as activities in mathematics and languages arts had been completed. With yet another new principal, the teachers expressed optimism about being able to teach science more frequently in coming years. In addition, teachers suggested that, over time, implementation of the Common Core standards could actually lead to more opportunities to teach science, to integrate science with reading and language arts, and to use inquiry-based instructional strategies. As one teacher explained, "I think the push to Common Core is going to be great for the students because they are now wanting to get back to [students] being thinkers."

The Hope teachers also identified a need for resources. Having more "license to teach other content areas" [beyond mathematics and language arts] could improve science education, but "we will still need the materials to be able to really expose the kids to it." Teaching science without the necessary hands-on materials limited the extent to which the teachers felt they could make the concepts meaningful and relevant to the students.

In terms of collegial support, the Hope teachers described a situation similar to Sequoia Elementary. No one else in their grade-level teams had participated in the professional development, and the other teachers at their school showed little to no interest in collaborating on science instruction. A first-grade teacher in the study missed not only the collaboration she had while participating in the 3 years of professional development but also the mentoring that the other participating teachers provided. Because two teachers who participated in the program had moved, she shifted from working closely with grade-level colleagues on science to essentially being on her own. In another situation similar to Sequoia Elementary, one of the Hope teachers moved from K-2 to an upper elementary grade assignment after the professional development ended. Of the three remaining participating teachers at Hope, she spent the most instructional time on science. In addition to her personal interest in teaching science, the fourth-grade curriculum made it more feasible to teach science for longer time periods.

In terms of needed supports, the Hope teachers most frequently identified administrative support, materials, and follow-up professional development. Teachers sensed that administrative support would enhance their ability to teach science more frequently and to secure funding for supplies. Some follow-up professional development sessions, they believed, would allow them to bolster their content knowledge and to share ideas and collaborate with other participants.

Significant Decrease in Instructional Time

Although still higher than at Hope and Sequoia, the participating teachers' median instructional time in science at Newcastle Elementary and Lewis Elementary decreased during the second and third years after the program ended (see Fig. 1).

Newcastle Elementary School

Newcastle Elementary is the smallest of the case-study schools with approximately 225 students who are predominantly Hispanic (88 %). Approximately 92 % of the students qualify for free or reduced lunch and approximately 60 % are English language learners. At Newcastle Elementary, the median instructional time dropped from 105 to 70 min per week. The Newcastle teachers identified time in the school day as the main obstacle to teaching science. A key factor that increased demands on instructional time was the school's designation as a program improvement (PI) school by the state. Schools that do not meet statewide proficiency goals for two consecutive years are designated program improvement schools by the state and are subject to improvement and corrective action measures. Given that mathematics and language arts are emphasized on the standardized tests in the early elementary grades, teachers across schools felt the need to focus on those two subjects, but a shift to program improvement status increased the press on Newcastle faculty to improve test scores. One teacher referred to the school's lower test scores as a key reason that science was not "as big a focus as reading and math." Another teacher described,

> The biggest barrier is time. We have so many things we have to do with language arts and math and now we are in PI this year… I don't think our administrator would necessarily forbid us from teaching science but she has to answer to that as well.

Although the teachers did not have to follow a pacing guide in terms of time spent on each subject, they expressed frustration about "trying to find enough time for everything." One teacher described spending about 4 h a day on language arts and "then kind of plugging in everything else." She indicated that she "would definitely spend more time [on science] if I could. It is just kind of hard to cram everything into one day." Given the large population of English language learners at Newcastle, professional development at the school level emphasized language arts and ways to incorporate language strategies into other subjects. For some teachers, this emphasis provided an opportunity to combine language arts and science.

The teachers did not identify administrative support as an obstacle to teaching science and in fact described the principal as supportive of science and of integrating it into other subject areas. Their concerns centered more on the principal's multiple aims. As one teacher described,

> Our administrator has a very broad vision of what she wants us to accomplish and do. And sometimes we have so many things that she wants us to get finished in a certain amount of time… that it really becomes overwhelming.

In addition to time demands, a lack of resources for materials influenced teachers' decisions about conducting experiments or doing other inquiry-based activities in science. Sometimes teachers would adjust their instruction:

> You know experiments or things you want to do with the kids. You don't have the resources to get those things. So sometimes I [decide] no, we're not going to do that one. I'll have to think of another lesson because I can't get the materials for that. There just isn't money for supplies and materials.

Another approach was to "ask parents to support me with what they can… It's easier for them to buy a pack of 5 [bulbs] for a couple of dollars than for me to get enough for the whole class."

Teacher collaboration at Newcastle occurred primarily in grade-level teams, and the teachers who completed the program were in different grade levels. Although they sometimes shared ideas about classroom activities, the teachers did not have the same level of collegial support in science as they had experienced during the professional development. One teacher described sharing science strategies with a new teacher in her grade level, but this new teacher seemed less invested and less "willing to put effort into it on his own." She observed him teaching science and "he was reading out of the book and that was it." Another participating teacher described a similar situation in which colleagues who had not participated in the program viewed inquiry-based strategies as too time consuming and "did not understand the benefits of using it and how much it really works."

For the Newcastle teachers, the drop in instructional time in science reflected changing demands. With the school's new designation as a program improvement site and the implementation of Common Core standards, teachers struggled to meet their aims in science. One teacher wanted to teach science every day, but "with the new Common Core push, I probably only end up getting to it about three times a week. I have been struggling with time management with this transition. We have been pushing certain things and trying to fit everything back into my days has been my struggle this year."

The most frequently requested supports of the Newcastle teachers were materials, follow-up professional development, and collaboration with teachers at their school and program participants from other schools. As one teacher stated, "Sometimes it is just the materials and supplies…You have experiments or things you want to do with the kids, but you don't have the resources to get those things." They proposed that "even once a year or every couple of years to somehow reconnect with the people who were in the program" would be helpful "to look over what we've created and then kind of tweak it with each other or talk about how it has been implemented." Follow-up sessions would offer an opportunity "to talk about these ideas we learned and try to remember everything."

Lewis Elementary School

Lewis Elementary's population of approximately 450 students is primarily Hispanic (60 %) and White (37 %) and includes approximately 52 % English language learners. Over 60 % of students qualify for free or reduced lunch. At Lewis Elementary, the median instructional time dropped from 125 to 100 min during the second and third years after the program ended. The Lewis teachers, like the Newcastle teachers, pointed to time in the school day as the primary barrier to teaching science. The teachers explained:

> [The challenge is] just really trying to squeeze everything in. And this year we're focusing on the Common Core and our main focus is math and writing. So those are my main focuses right now.

> A big thing is time… We have been heavy on Common Core and so we're trying to do a lot more math and writing, and there's hardly any time.

Another Lewis teacher suggested that the pressure to focus on mathematics and language arts had increased since the professional development program ended. Program improvement status, in combination with adoption of the Common Core standards, had heightened the emphasis on mathematics and language arts in the curriculum. In contrast to Newcastle, Lewis had been designated as a program improvement school for years and that ongoing status, according to the teacher, led to added pressure: "We've been dealing with it for a while. But kind of the further and deeper into program improvement we get, the more pressure we get from our district." In addition, "because it is second grade, it is the first year of [students] taking the [standardized] test. It is just so much added pressure from the district." A first-grade teacher similarly described the school's focus as stemming from student performance on standardized tests: "From our scores, it kind of shows that we need to push our reading and math; and at the lower grades, we don't test in science. I feel like that is why there's not as much support [for science] as reading and math."

The principal at Lewis Elementary changed more frequently during the study period than at the other schools. One year the school ended up with two people from the district office acting as part-time principals and splitting the responsibilities. These frequent changes in school administration resulted in changing curricular demands and support for science. One teacher indicated that "The principal we had when we signed up for [the program] was a little more supportive of science and since then, there hasn't been much support." Another teacher suggested that the various principals had not provided resources or direct support for science but had "seemed fine with what we were doing." As one teacher phrased it, one of the principals seemed more approachable "if we needed something" but "none of them pushed science."

The Lewis teachers reported minimal collaboration with other teachers about science curriculum and instruction. Although grade-level teachers had formal meetings each week, teachers described the sessions as "focusing more on getting new report cards ready for the Common Core, that kind of thing." One teacher's statement summarized the perspective of many: "I don't feel like I have a lot of help and I definitely had more support when I was in the [PD] program." Due to changes in teaching assignments, teachers who had completed the professional development program together were teaching at different grade levels. A teacher who had shifted from second grade to kindergarten pointed out the difference in collaboration:

> In second grade, my colleague went through [the program] with me, so we kind of planned together and came up with lessons together. Now I'm more on my own and trying to get through math and language arts and squeezing science in.

This teacher noted that her current grade-level team tended to collaborate more on Guided Language Acquisition Design (GLAD) because, unlike the science professional development, all of the teachers in the team had completed the GLAD program.

Despite the competing demands for instructional time, Lewis teachers reported using the inquiry-based investigative strategies and other processes they learned during the 3-year program, but they tended not to develop new lessons or incorporate more science into the curriculum. One teacher stated, "I haven't really changed anything since then. It's pretty much stayed the same since [the program] ended." Another teacher described the "lasting impact" of the program and how the strategies she learned "complement the way that I like to explore and have children learn from each other and not just me." When teaching science, Lewis teachers continued to draw upon strategies learned in the professional development, but a lack of support and increased demands on instructional time lessened the time devoted to science instruction.

The most frequently requested supports by the Lewis teachers were opportunities for collaboration and continued professional development. The teachers particularly missed the sharing and collegial support they experienced with the larger group of participants:

> I think being able to talk to somebody is the biggest for me. Because it would always be nice to know more where I can find more information about something or other ideas or experiments.

> I am interested in working with other teachers. Working with other teachers and getting more ideas and trying things.

Similar to teachers at other schools, the Lewis teachers wanted periodic "refreshers so that you don't forget everything… you had worked on and learned." One teacher proposed sessions that could refresh their knowledge about "both the content and the instructional strategies."

High Instructional Time

Canyon Elementary School

Canyon Elementary's population of just under 600 students consists primarily of White (77 %) and Hispanic students (12 %). Canyon Elementary, like the other case-study schools, is a Title I school; approximately 54 % of the students qualify for free and reduced lunch. At Canyon, participating teachers' median instructional time in science increased from 105 min per week to 135 min per week during the second and third years after the program ended. Four contextual factors that contributed to sustained instructional time in science at Canyon Elementary included: administrative support, resources, teacher collaboration, and personal motivation.

In interviews, teachers described both their principal and district superintendent as supportive of science instruction. An important form of administrative support was allowing teachers more control over the curriculum. Canyon teachers identified time as an ongoing challenge in teaching science, but they had more flexibility than teachers at other schools to incorporate science into the curriculum. The principal supported integrating science into other subjects and did not require adherence to strict pacing guides. As one teacher stated, "We feel like we really incorporate standards with everything we do, but we don't have a rigorous administration that checks into make sure." Another teacher noted how the principal "loves watching how we have so much science; he loves coming in and observing [science] and he knows that we are not just doing math for 3 h." The principal demonstrated interest not only in the teacher's classroom instruction but also in other science-related activities. For example, both the principal and the superintendent participated in the school's science night and "engaged with the kids." At Canyon Elementary, teachers encountered less administrative turnover than at other schools. When the school was assigned a new principal after 8 years, an assistant principal moved into the position. Consequently, administrative priorities and support tended to be more stable during and after the professional development program.

In contrast to teachers at other schools, the Canyon teachers did not identify resources as a primary obstacle. The parent–teacher association helped cover costs for a science night and provided parents for in-class lab support. A first-grade teacher described having "four parents and myself when we dissected owl pellets." Another teacher described how the principal had "little sheets for us to give him feedback about where we're lacking and that way if we needed more support, we have an opportunity to tell him what we need or what's happening."

The Canyon teachers also benefited from ongoing collaboration through grade-level and school-wide meetings. In contrast to some of the other schools, the second-grade team at Canyon Elementary had two teachers who had participated in the professional development program, which enhanced their collaboration on science instruction. For example, one second-grade teacher commented, "We hear ideas…'What are you doing in science and where are you and how did you do that?'…We put these kits together so when it comes time for us to do that hands-on lesson, everything is right there and we just share it." Although she was the only program participant in her grade level, the first-grade teacher also referred to discussing and "putting together [science] lessons" in grade-level meetings.

The Canyon teachers exhibited personal motivation to teach science that was fueled by student interest. In response to a question about factors that influenced her instructional time in science, one Canyon teacher stated, "I think the interest level. The kids love it. That's what has made me want to do more of it because the kids like it and the interest level is there." Another teacher commented about realizing how important science is and how it "builds upon what they're interested in. [Consequently], I don't find myself saying, 'Gosh, there is just not enough time' because I have made time." With the flexibility to integrate science with other subjects, the Canyon teachers could capitalize on their students' interest to more frequently include science in the instructional day.

The Canyon teachers thought additional professional development and collaboration with teachers outside of their own school would be helpful. As one teacher pointed out, "With 3 years of science, I'm not a guru. I think you should continue to learn and take as many classes as you can." Another teacher suggested, "I think what is most helpful is getting together with other teachers and sharing good ideas so if there was a little refresher course or something." In contrast to the teachers at other schools, the Canyon teachers did not request materials or collegial support within the school. One teacher summarized the overall perspective this way:

> I feel like I have good supplies. I feel like I have good resources. I have good collaboration with my peers. But you do forget and there's also better things happening all of the time and better lessons or new ways to do things.

Cross-Case Patterns

Our cross-case analysis highlights five key findings about the influence of contextual factors on sustainability of professional development outcomes. First, school principals played a central role in facilitating or hindering K-2 science instruction after the professional development ended through factors such as instructional expectations, curriculum and pacing guides, resource allocations, and collaboration time. In schools that had significant turnover in principals, teachers found it challenging to adjust to changing instructional expectations, particularly when those expectations focused almost exclusively on language arts and mathematics. Without the license to teach science that accompanied participation in the professional development and facing competing demands from school administrators, teachers in those schools struggled to fit science into the instructional day. In addition, some principals required strict adherence to curriculum and pacing guides and did not allow integration of subjects, but in other schools, teachers had flexibility to integrate science into other content areas. Principals also influenced the amount of time allocated for teacher collaboration and the focus of those collaborative efforts as well as resources allocated for science-related materials, supplies, and events such as Family Science Night. In schools with higher instructional time in science, teachers reported more direct support of science by the principal and more flexibility in their curricular decisions.

Second, external factors such as state-level program improvement designations and adoption of Common Core standards had differing impacts across schools. All of the case-study schools were in the process of adopting Common Core standards, which introduced new instructional demands, but, at some schools, the implementation process placed more emphasis on language arts and mathematics than at others. Similarly, a school's designation as a program improvement site affected the principal's expectations and teachers' decisions about instructional time at some sites more than others. The influence of PI status was particularly evident at schools that were placed on PI status after the professional development ended. Teachers in these schools described a shifting, increased focus on language arts and mathematics that influenced their science instruction. Teachers in the schools with the least instructional time in science reported mandated time schedules for instruction in mathematics and language arts and no flexibility to integrate science into those subjects. Even when principals supported teaching science and integrating science into other subjects, teachers felt the press to increase students' test scores in mathematics and language arts due to PI status and expectations "to accomplish so many things in a certain amount of time."

Third, teachers with ongoing collegial support at their school were better able to sustain instructional practices learned in professional development. The teachers in this study who reported the most collaboration on science instruction were in a school with ongoing grade-level or school-wide meetings and at least two program participants in their grade-level team. During the third year after the program ended, this school had the highest reported instructional time in science. These teachers appreciated being able to share ideas and work with colleagues on planning for science lessons. They also benefited from shared resources such as kits for hands-on science activities. In contrast, at other schools, teachers met regularly in grade-level teams but discussions of other subject areas took priority. Similarly, colleagues who had not participated in the program often did not share an interest in using inquiry-based strategies in science, so there was little or no collegial interaction related to science teaching in some schools. Teachers without collegial support for science particularly missed the collaborative planning and preparation of materials that they experienced during the professional development and the motivation that stemmed from working with others who were excited about teaching science.

Fourth, teachers with high personal commitment to teach science and use inquiry-based methods found ways to do so, but schools should not rely on individual drive to overcome contextual factors. Despite changing contextual factors, the teachers who had the most personal motivation and interest in science found ways to continue teaching it and to use investigative strategies. They made comments about "making time" and continuing to "use all those strategies that I learned," and being "still excited about teaching science." They talked about how the professional development they experienced "inspires you to teach science" and provides "great strategies that keep kids engaged." For two teachers, individual motivation in combination with a change to an upper-grade assignment facilitated increased instructional time in science. They identified the longer instructional day and increased student attention spans as enabling factors.

Fifth, teachers' most frequently requested forms of support were modest, but hold important potential for sustaining science instruction. Across schools, participating teachers recommended periodic follow-up professional development to refresh their knowledge of content and instructional strategies in science. They did not request extensive professional development but rather 1 or 2 days a year. These follow-up sessions would also allow opportunities for teachers to reconnect with other participants, a form of collegial support and instructional sharing that they missed after the program ended. In addition, follow-up sessions could be targeted and adapted to teachers' needs; for example, teachers were familiar with strategies such as scaffolded-guided inquiry but desired help in determining how to modify the model to fit within a shorter time period. After spending 3 years in the program, teachers lamented its abrupt ending. A staged exit, or progressive reduction in follow-up sessions, may provide enough support for teachers to sustain the changes they made during the program. Teachers also identified a need for more collaboration with colleagues about science at their school sites. At the school with the highest median instructional time in science, teachers benefited from ongoing collaboration in their grade-level team. At other schools, teachers found themselves "on their own" when it came to science. At most of the schools, teachers expressed the need for supplies to conduct experiments and other activities. They did not suggest expensive equipment but rather funding for consumable items that needed to be replenished each year.

Conclusion

This study demonstrates the influence of context on the sustainability of professional development outcomes and holds implications for research and practice in science education. Context is an important mediating influence on not only the extent to which professional development leads to changes in teachers' instructional practices (Desimone, 2009), but also the extent to which those practices persist over time. A report from the National Academy of Sciences (2015) concludes that science teachers' development should be perceived as long term and contextualized. Identifying the contextual factors that influence long-term changes in science education is the first step in formulating strategies for sustainability. Our findings suggest that ongoing yet modest support for teachers may help maximize the longevity of professional development outcomes in science. These supports may be particularly important for teachers in the early grades. In contrast to the upper elementary grades, the instructional day in the early grades is shorter and focused primarily on mathematics and language arts. These differences tend to provide upper-grade teachers with more flexibility to include science in the instructional day and to use inquiry-based methods.

As highlighted in this study, school contexts vary considerably, even within the same district or geographic region. Differences in teachers' science instruction after participation in professional development reflect these variations in school context. Administrative and collegial supports are particularly important to teachers in sustaining science instruction, and these supports not only vary widely across schools but also across years. School principals may be reassigned for multiple reasons, but frequent shifts in administration require teachers to adjust to shifts in expectations and priorities. In this study, teachers in schools with high turnover of principals encountered more challenges in maintaining science instruction over time. Collegial support for science also shifts over time as teachers retire, move to different schools, and change grade levels. When a school has a pool of teachers who participated in the professional development and share an interest in teaching science, collegial support is enhanced. Since most curricular and instructional planning takes place in grade-level teams, teachers particularly benefit from having fellow professional development participants in their grade level. Variations in school context also influence the extent to which state-level factors affect teachers' decisions about science instruction. For example, the process of adopting Common Core standards led to increased instructional demands in mathematics and language arts at some schools but not others.

In demonstrating the variation and importance of contextual factors, this study reinforces the need for research that investigates the influence of context on the sustainability of professional development. Longitudinal studies in a range of settings will help to clarify the relationship between contextual factors that are beyond the teachers' control and the persistence of changes in science teaching practices after professional development ends. The role of the school principal in sustaining science instruction over time in the early grades is particularly important. Whereas studies have reported that principal support is linked to changes in teachers' practices stemming from professional development (Banilower et al., 2007; Guskey & Sparks, 2002), the literature lacks longitudinal studies that specifically examine administrative support in science after professional development ends. To develop viable plans for follow-up support, we need to know more about how differences in school contexts affect teachers' ongoing decisions about how much time to devote to science instruction and what pedagogical strategies to use.

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Appendix: Coding Categories for Teacher Interviews

Instructional time
Time spent on science instruction
Changes in instructional time on science
Factors influencing instructional time
Science curriculum
Changes in curriculum
Factors influencing curricular decisions
Instructional strategies in science
Strategies used
Changes in strategies
Factors influencing instructional strategies
Scaffolded-guided inquiry (SGI)
Student notebooks
Integration strategies
English language strategies/science
Math/science

Resources/supports
Administrator support
Support from other teachers
Available supports/resources
Needed supports/resources
Teacher collaboration
With participating teachers at own school
With other teachers at own school
With participating teachers at other schools/districts
Teacher leadership
Barriers
Not enough time
Not fully understanding how to use strategy or tool
Lack of alignment
Lack of support
Self-efficacy in teaching science
Content knowledge
Knowledge of science
Pedagogical content knowledge
Impact on students
Sustainability of changes
Lack of (added as double code to any category)
Other

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