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School Science Capacity: A Study of Four Urban Catholic Grade Schools

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Working from the view of schools as a system, and of school improvement as an ongoing journey (Hallinger & Heck, 2011; Jackson, 2000), this study investigated the perspectives of teacher leaders and principals from four metropolitan Catholic grade schools engaged in efforts to improve their school science programs. Built upon existing conceptualizations of school capacity, a model of school science capacity is presented and used as a framework for the development of four case studies. Findings gleaned from collecting and analyzing reports of teacher leaders' and principals' interpretations of their school systems illustrate how elements of the school science capacity framework interacted to support and at times constrain, the schools' science improvement efforts. Implications for Catholic school educators, administrators, and researchers who seek to make science a priority, and build school science capacity, are discussed.

Keywords

Science Education, School Improvement, School Capacity, Systems Thinking

A defining characteristic of Catholic education is a commitment to educating the whole child through the work of a genuine community of persons (Ozar & Weitzel-O'Neill, 2012). Similarly, systemic views of teaching and learning originate from the understanding that teachers' activities fit within an "interactive web" (Spillane, 2005, p. 144) of social structures. Teachers, administrators, school staff, families, and communities all depend on one another as they come together to educate children, a formidable task that is impossible to attain single-handedly. Thus, understanding a school's effectiveness requires consideration not only of the interdependent parts, but also of how they function together. Although a growing body of scholarship has considered how schools as a whole are organized to support mathematics and reading achievement (Bryk, Sebring, Allensworth, Luppescu, & Easton, 2010; Hallinger & Heck, 2011), this study responds to a call from within the

science education community for the adoption of systems perspectives when investigating student success in science (Fraser-Abder, Atwater, & Lee, 2006; Lee & Krajcik, 2010; Settlage, Butler, Wenner, Smetana, & McCoach, in review; Smetana, Wenner, Settlage, & McCoach, in review; Wood, Lawrenz, Douglas, Huffman, & Schultz, 2006). In addition, this study responds to a call from within the Catholic education community to make researching Catholic schools a priority (Frabutt, Holter, & Nuzzi, 2013; O'Keefe & Scheopner, 2007). The purpose of this study was to investigate the perspectives of teacher leaders and principals from four urban Catholic grade schools that are engaged in efforts to improve their school science programs. These efforts, discussed in further detail later in this article, arose for different reasons at each school, but were all internally motivated. In some cases, there was a desire to improve upon an already strong science program; in other cases, reform efforts were driven by a recognized need for more learner-centered, inquiry-based science experiences, particularly in order to remain competitive with the offerings and outcomes of other area schools. This research intends to contribute to a better understanding of school-level leadership and organizational features specific to Catholic schools, and to clarify how elements of a school's capacity (Dimmock, 2012; Newman, King, & Youngs, 2000) interact in unique ways to support school science improvement efforts.

This article begins with background on the literature that supports a systems approach to school-wide science improvement efforts, as well as the challenges that schools face, focusing on Catholic schools in particular. The article's conceptual foundations are then discussed. Next, the research questions and methods used to address these questions are presented, followed by a report on the understandings that we, as the researchers, uncovered about each school's organizational and social structure, as well as their science improvement efforts. The article concludes with a discussion of implications for Catholic school educators, administrators, and researchers who seek to make science a priority.

Challenges to School-Wide Science Improvement

There is robust evidence demonstrating that school-level factors (Konstantopoulos & Borman, 2011), including school social structures (Khourey-Bowers, Dinko, & Hart, 2005) and school leadership (Robinson, Lloyd, & Rowe, 2008), significantly impact classroom practice and overall student achievement. However, science education research has typically focused on

the individual or classroom level (Roth, Tobin, & Ritchie, 2008; Wood et al., 2006). Investigations that primarily focus on particular instructional strategies or curricular approaches and materials often neglect consideration of the relationship between teachers' efforts within the classroom and the larger school context. For instance, teachers' innovative classroom practices can be minimally impactful beyond their classrooms unless there is a social context that will ensure those practices can take hold school wide (Halverson, Feinstein, & Meshoulam, 2011).

There is also increasing support for the conclusion that "subject matters" when investigating issues of school effectiveness (Spillane & Hopkins, 2013, p. 721). Formal support for science teaching and learning is typically secondary to that designated for literacy and mathematics at the local, state, and national levels. For instance, time dedicated to science is considerably less than time dedicated to math and literacy (Jones, Jones, & Hargrove, 2003; National Center for Education Statistics [NCES], 2007), and, for better or worse, less attention is paid to how that time is used (Halverson et al., 2011; Southerland & Sampson, 2012). Funds and other resources like instructional specialists or coaches are also less likely to be allocated to science (Spillane & Hopkins, 2013). Additionally, there are staffing factors to consider, as teachers have varying degrees of experience, interest, and comfort with different academic subjects. Typically trained as generalists, elementary grade teachers may feel unprepared to facilitate students' science learning (Fulp, 2002; Weiss, Banilower, McMahon, & Smith, 2001). Finally, the way that teachers and administrators organize for instruction differs by subject area, depending on their levels of comfort with the subject matter (Spillane & Hopkins, 2013; Supovitz, Sirindes, & May, 2010). Specific challenges cited for Catholic schools include a lack of a coherent curriculum (Bryk, Lee, & Holland, 1993; Mayotte, Wei, Lamphier, & Doyle, 2013) and the absence of systematic, longitudinal approaches to teacher professional development (Lucilio, 2009; Mayotte et al., 2013). The problem of promoting school-wide science initiatives is often compounded by limited teacher release time and funding to allow for engagement in meaningful professional development and other opportunities to collaborate with fellow teachers and administrators (Mayotte et al., 2013; Moore, 2000).

Conceptual Framework: School Science Capacity

School Capacity

In education, capacity is defined in a variety of ways (Beaver & Weinbaum, 2012) and used in reference to the potential or ability to accomplish the core goal of schools, to further student learning and development. For the purposes of this research, we adopted Newman et al.'s (2000) definition of school capacity as "the collective power of the full staff to improve student achievement schoolwide" (p. 261). Emphasis on collective power stems from our perspective of schools as social organizations comprised of interconnected relationships that include students, families, teachers, administrators, support staff, and communities (Elmore, 1995; Roth et al., 2008; Spillane, 2005). The assumption is that the sum is greater than its individual parts. An individual teacher's knowledge, skills, and dispositions are important for the success of the students in that classroom (Nye, Konstantopoulos, & Hedges, 2004); yet, for students to successfully matriculate, a given teacher's expertise must be applied in ways that promote the collective success of the entire school (Heck & Hallinger, 2010). Therefore, other conditions must support individual efforts at the school level, evidenced in certain necessary components of a school's capacity, including individual teachers' knowledge, skills, and dispositions, as well as resources in the form of a professional community, academic program quality and coherence, academic focus and expectations, student support systems, technical resources, and leadership (Dimmock, 2012; Hallinger & Heck, 2011; Newman et al., 2000; Youngs & King, 2002). Seeking to understand the type of leadership that effectively builds school capacity in today's increasingly complex and fast-changing environments, Dimmock (2012) argued for consideration of the moral imperatives that drive the work of schooling, as well as the contextual conditions in which a school is situated.
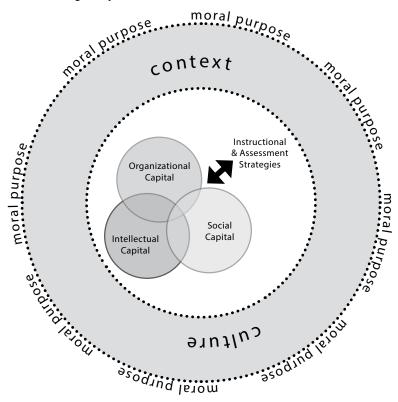
School Science Capacity Model

Figure 1. Framework of school science capacity.

To investigate school-level leadership and organizational aspects that support science success from a systems perspective, we built upon existing conceptualizations of school capacity. Essential elements of our model of school science capacity, depicted in Figure 1, included the school's: (a) moral purpose, (b) context, (c) culture, (d) intellectual capital, (e) social capital, (f) organizational capital, and (g) instructional and assessment strategies. Although these elements are not necessarily specific to science, we applied the framework to our analysis of school science programs. Each aspect of this model is summarized below in order to provide background about the framework that guided the present study.

In this model, *moral purpose,* positioned as an exterior backdrop to indicate how it encapsulates and interacts with the rest of the elements, refers to the common mission, fundamental values, guiding principles, and collective

sense of direction of the school. The core work of schools, educating children, is itself both an intellectual and a moral activity, and one that provokes the important question of "leading and teaching to what ends and by what means?" (Greenfield, 2004, p. 174). The moral purpose is distinguished by a deep social responsibility that frames the core work of a school community (Bezzina, 2012; Fullan, 2001); the school's values and ethics are made public and explicit, so that members of the school community can take ownership of, internalize, and use them to guide their collective work. Catholic schools frequently share some fundamental values (Bezzina, 2012), such as respect, dignity, community, openness, common good, and service to others (Ozar & Weitzel-O'Neill, 2012), endowing explicit moral purpose that has the potential to encapsulate and frame all science capacity-building efforts.

In the two inner rings of the model, *context* refers to the school environment, size, and physical and financial resources, as well as its demographics and its reputation. Culture refers to the organizational ethos of the school, including its norms and customs, which provides insight into how the school operates (Hollins, 1996). The prominence of context and culture in the model are intentional, as "the importance of situatedness in enhancing capacity cannot be dismissed" (Stringer, 2009, p. 170). Teaching, learning, and leadership are not isolated from the larger organizational systems and environments in which they function, nor are context and culture static phenomena; thus new challenges and opportunities that consistently arise from these elements must be taken into consideration (Hargreaves & Fullan, 1998; Louis, Dretzke, & Wahlstrom, 2010; Opdenakker & Van Damme, 2007). Three forms of capital—intellectual, social, and organizational—are at the center of Figure 1, indicating their centrality. The overlapping configuration of these elements illustrates their interdependent, dynamic relationship with one another. *Intellectual capital* refers to the type, level, and depth of knowledge, skills, and dispositions that school professionals possess relevant to teaching and learning (Louis et al., 2010). It is important to look beyond what capital currently exists in a school and to question how intellectual capital is developed, supported, and valued in the school, asking, how—and to what extent—are teachers intellectually stimulated? How—and to what extent—is teachers' continued learning supported?

Another form of capital, *social capital*, represents the intangible resources that are embedded within, and transmitted through, the fabric of social relations and social structures, as well as how individuals access and make use of these resources (Coleman, 1988). Coleman (1988) has described three pri-

mary components of social capital: (a) information channels, which facilitate knowledge-sharing and access to pertinent information and resources; (b) group norms, which encourage commonly agreed upon positive actions and constrain other undesirable actions; and (c) interpersonal trust, which supplements formal control mechanisms (i.e. rules, policies, procedures, and hierarchies) and reduces vulnerabilities between individuals.

Finally, *organizational capital* refers to the type, level, depth, and breadth of organizational leadership ability, characterizing leadership as: (a) a collaborative property of a social system, rather than of a single individual (Yukl, 1994); (b) an adaptive practice, the success of which is evidenced in outcomes that result for the social system; and (c) part of a dynamic, mutually influencing relationship with other school improvement variables. Whether referred to as a collective, collaborative, or distributed leadership perspective (Spillane, Halverson, & Diamond, 2001), we recognize that there are multiple sources of and opportunities for leadership influence within a school—beyond the principal or others who hold formal administrative positions. Additionally, one's repertoire of leadership abilities can, and arguably must, develop and expand over time (Jackson, 2000). Thus, for our purposes, organizational capital included characteristics and efforts associated with the leadership abilities of the school principal and classroom teachers, and the extent to which the school provided opportunities for multiple individuals to further develop and contribute those leadership abilities.

Finally, *instructional and assessment strategies*, on the opposite side of the interior of Figure 1, describe the common teaching and learning practices—in this case, specific to the school's science program. Of interest here is not only what curricular and instructional materials and approaches are utilized (i.e., whether they are effective, challenging, meaningful, appropriate, up-to-date, research-based), but also the degree to which the school community takes a reflective stance (Cochran-Smith & Lytle, 2009) toward its pedagogic and assessment practices. This element of the framework also considers the degree of consistency, although not uniformity, in the teaching and learning practices across the school. Because teachers and administrators are engaged in, and making decisions regarding, the strategies, the linking arrows represent the inherent relationship with the three forms of capital.

To examine not only these individual aspects of school science capacity, but also their interaction in particular Catholic school settings, we posed the following research questions:

1. How do teachers and administrators discuss aspects of their schools' science capacity?
2. In what ways do these aspects interact to support and at other times constrain science improvement efforts?

Methodology

Interpretive Case Study

We employed a case study methodology to investigate the complex system of school science capacity and the unique relationships among the various elements within that system. By examining particular cases of Catholic schools at different points in developing their science capacity, our purpose was to generate more nuanced understandings of the different components and processes involved in building school science capacity, as reported through the participants' interpretations of their own school systems. Interpretation was a key element of this case study (Stake, 1995), as the goal of the research was to rely primarily on participants' views of their school science capacity and how they constructed meaning regarding its development and their role in building it, as evidenced through interview and focus group conversations (Creswell, 2009). To highlight experiential understanding and multiple realities (Stake, 1995), this study analyzed the views of various stakeholders involved with each school case. This was accomplished through the development of case profiles, whereby we interwove these varying perspectives and used thick description (Geertz, 1973) to emphasize the particular situations, settings, organizational structures, contexts, cultures, and so on, of each school case (Willis, 2007).

Participants

Participant schools were Catholic elementary schools affiliated with the Archdiocese of a large Midwestern city. All of the schools were involved to some degree in an Archdiocesan initiative to develop and implement new inquiry-based curriculum units in science and social studies, aligned with updated state standards, such as the Common Core State Standards and the Next Generation Science Standards, and emphasizing interdisciplinary, hands-on, and investigation-based science teaching and learning. A representative from our university who was working closely with the Archdiocese on

this initiative identified these schools as potential participants for the study because they were involved in efforts to build their school science capacity, through both the implementation of inquiry units and other initiatives. Principals of four schools agreed to participate in the study and identified science teacher leaders on their faculty who also agreed to participate and contribute teachers' perspectives on the development of school science capacity. Table 1 shows some of the defining characteristics of the four participant schools.

Table 1
Defining Characteristics of the Four Participant Catholic Schools

School	Total Enrollment	Racial Demographics	Percentage of Students Qualifying for Free/Reduced Lunch	Participants
St. Anna	430 students from PK–8	71% White, 14% Biracial, 9% Hispanic, 5% Asian or Asian/Pacific Islander	1.7 %	Adele (PRINCIPAL) Amy (GRADE 2) Aaron (GRADES 4 & 5) Andy (GRADES 6, 7, 8)
St. Natalia	480 students from PK–8	64% White, 10% Asian, 10% Biracial, 8% Hispanic, 7% Black	20.6 %	Nancy (PRINCIPAL) Natalie (GRADES 6 & 7) Naomi (GRADES 6 & 7) Noreen (GRADE 8)
St. Rupert	270 students from PK–8	46% Hispanic, 39% White, 8% Asian or Asian/Pacific Islander, 6% Biracial, 1% Black	42.7 %	Ruth (PRINCIPAL) Rachel (GRADES 6, 7, 8)
St. Stephen	100 students from PK–5	44% White, 35% Hispanic, 15% Asian or Asian/Pacific Islander, 4% Biracial, 1% Black	Exact data not available; <10%	Sharon (PRINCIPAL) Sandra (GRADE K) Sue (GRADE 3) Sarah (GRADES 4 & 5)

Data Collection

Data collection for each school included a principal interview and a focus group with science teacher leaders. Focus groups were used to obtain the teacher leaders' perspectives to uncover the perceptions of multiple teachers. In one school case (St. Rupert), however, only one teacher was available to

participate, and thus took part in a teacher interview instead. The dynamic format of the focus group enhanced the interpretive aspect of the case study because it allowed for discussion and interactions that generated unique data and insights, which would not have been possible to obtain in one-on-one interviews (Morgan & Krueger, 1993). Furthermore, the same semistructured protocol was used to guide interviews and focus groups with both the principals and the teachers, so that responses could be compared and multiple interpretations within cases could be considered and analyzed. Data collection documents, including both the interview and focus group protocol, were specifically aligned to the Framework of School Science Capacity Presented in Figure 1 to probe each element. The tools and alignment are presented in the Appendix.

Data Analysis

Data analysis followed Erickson's (1986) guidelines for analytic induction. The process began with transcribing each interview and focus group and collaboratively developing a code book (DeCuir-Gunby, Marshall, & McCulloch, 2011), which contained a set of theory-driven and data-driven codes, definitions, and examples. This codebook served as a guide for the iterative analysis of the interview and focus group data, using codes that corresponded with the seven aspects of the school science capacity model laid out in the conceptual framework. Each interview and focus group transcript was initially coded independently by both researchers, who then met regularly to discuss emerging themes and patterns, perform intercoder reliability checks, and discuss any discrepancies. School profiles were then written for each school to highlight the uniqueness of each case and to offer a comparison of the leadership and organizational features of the four participant schools. These profiles served as an additional form of analysis, as they were specifically written to address the various aspects of school science capacity from the model depicted above. Finally, in a subsequent round of coding, themes were identified across the four cases and across the previous codes. These multiple cycles of coding and analysis were conducted to produce findings that highlight the dynamic process of developing school science capacity and to emphasize the interaction between the various components involved in this process.

As described earlier, this study focused on the perspectives of both principals and teachers within each particular school case. While the data are lim-

ited to self-reported interpretations of participants, we ensured authenticity in our analysis by taking into account multiple perspectives and by investigating what these interpretations meant in relationship to one another (Lincoln & Guba, 1986). Furthermore, trustworthiness was ensured through the triangulation of data from different sources, cross-checking conducted between researchers throughout the analysis process, as well as the use of thick descriptive data in the profiles (Lincoln & Guba, 1986). The findings are not intended to provide causal explanations for the development of school science capacity, but rather to provide naturalistic generalizations for the reader, or the "stimulation of further reflection optimizing readers' opportunity to learn" (Stake, 1995, p. 42) from the complex cases, which represent various trajectories toward building school science capacity.

Findings

This section introduces some of the nuanced understandings about each school's organizational and social structure uncovered through teacher focus groups and principal interviews. First, the school profiles offer insight into how participants described various aspects of the school science capacity model. Then, differences and similarities across schools regarding aspects of school science capacity are presented and discussed in terms of supporting or constraining school science improvement efforts.

School Profiles

St. Anna. Stable, but not complacent: "We're up there and we're holding." St. Anna was affiliated with a parish in a city neighborhood whose demographics had shifted over the past decade, from including a variety of ethnic and racial backgrounds to becoming more gentrified, with the primary population being White, middle-class families. Despite the changes in the neighborhood and the student population, the principal (Adele) provided consistent leadership throughout her 15-year tenure at St. Anna. With a steady administration and little turnover in the teaching staff, the school maintained a sense of stability. This period also involved updates to the curriculum and school facilities. For example, to ensure that it served all students' needs, St. Anna worked to develop partnerships with local nonprofits focused on identifying and supporting students with learning, social-emotional, and developmental disabilities and their families. St. Anna also began to offer accelerated

programs for students needing enrichment. Additionally, the school's historic building was renovated about 10 years previous to this study, and both middle school and upper elementary science labs were added to the building, which were being used by the departmentalized science classes in grades four through eight. These efforts had seen fruitful results; the school's TerraNova standardized science test scores were around the 74th national percentile, and during the 2013–2014 school year, the school received a Blue Ribbon School designation.

Despite this level of success, along with the changing demographics of the neighborhood came increased pressures for St. Anna to remain competitive with other top-ranking public, private, and parochial schools in the area. Principal Adele described the school climate as stable, yet not complacent, given the challenges of maintaining their enrollment in this climate:

> You [as a school] have to make sure you're competitive. . . . You try to get that across [to the faculty] that we can't let up. You have to stay on top. And that's the hard part because you know you always have to keep moving ahead.

For the principal, maintaining a competitive edge meant that instructional materials, curriculum, and faculty knowledge and skills need to be kept fresh and innovative. Because St. Anna did not receive public funding to support these endeavors, enrollment provided the necessary funding and, therefore, drove much of the decision making. Principal Adele discussed how the issue of funding curbed any complacency the school might have:

> Always moving the school ahead [is a major challenge]. You've got to have the [reasoning to] back up why we're doing the things we are. You can't stay stagnant. We're here because parents feel that we're doing a good enough job to warrant the enrollment staying up there. It warrants the revenue that comes in to support the jobs that we have. We don't have the revenue coming in if parents don't buy in to [what we're doing]. Parents' vocal support of science has also helped to drive some of the school's efforts to build science capacity.

As the intermediate grade teacher, Aaron, noted:

> I think a lot of parents recognize that [science] is where people's future

is going to be. I think they understand the importance of [STEM] subjects, even if they're not necessarily the biggest things that come up in standardized tests.

Participants explained that parents contributed to the school's push to remain competitive and focused on science and described a strong and collaborative relationship between families and the school. The principal attributed this positive relationship, in part, to her open door policy, which applies to both parents and teachers.

St. Natalia. Growing pains: "We still aren't quite there." St. Natalia was a consolidation of six different parish schools across three large neighborhoods in the city and located on two campuses: one for grades PK through five and one for grades six through eight. This consolidation came about, in part, because of a period of declining enrollment and debt; however, the principal (Nancy), having been at the school for 10 years at the time of this study, described St. Natalia as currently being on "the upswing." Science had historically been the school's weakest subject area, with outdated materials, little instructional time devoted to science, and students consistently scoring low on annual standardized testing. However, a recent partnership marked a turning point. St. Natalia received grant funding, along with support from a local university, which allowed them to update curricular materials and increase attention to science teaching and learning. Adopting the Archdiocese's inquiry-based curriculum units for grades PK through five and the Science Education for Public Understanding Program [SEPUP] curriculum for grades six through eight, St. Natalia now has TerraNova standardized science test scores that average around the 83rd national percentile. Their efforts had also earned them a Blue Ribbon School designation during the 2013–2014 school year.

Because of the recent grant award and other principal-led initiatives, such as implementing a coteaching model in the grade six and seven science classes, many changes had taken place at St. Natalia. Some of these changes were driven by the pressure the school felt to maintain its positive reputation and help graduating students gain acceptance to selective enrollment or other competitive high schools in the area. Noreen, the eighth-grade science teacher, shared, "The demands [from parents] on middle school teachers especially are high. They want their child to get into select enrollment schools, or elite Catholic schools." She noted that pressure from parents was also felt by the administration and was "definitely an influence on the admin[istration]'s

decisions and then on what we as teachers need to do in the classroom."

Both the principal and teachers recognized that the new initiatives to build school science capacity at St. Natalia represented a departure from what the staff had been used to, and so this transition has been accompanied by some growing pains. For example, Principal Nancy stated that "some grade levels are much more comfortable and very positive about [the new elementary science inquiry units] and a few others are just expressing frustration that it's not this pre-packaged, hand it to you sort of a thing." Middle grade teachers described feeling that many instructional decisions made by administration—such as the adoption of the new SEPUP curriculum—had been undertaken without consulting the teachers. One teacher explained, "There wasn't [teacher] input into the decision" (Natalie), while another teacher said, "I really embraced the SEPUP program and the change. However . . . I think that communication [from the administration] would be helpful. I always advocate for communication" (Noreen). What teachers perceived as a lack of communication from administration had resulted in some tenuous internal relationships, recognized by all participants, including Principal Nancy, who said, "I would say that we're building trust [amongst the faculty]. I don't know that it's there."

Through its growing pains, St. Natalia's principal had continued to spearhead various efforts to build instructional coherence, strengthen interpersonal relationships and trust amongst the faculty, and invest in social and intellectual capital. Examples included offering common grade level planning times, strengthening vertical collaboration across grade levels, involving teachers in more leadership roles within the school, and pairing novice teachers with mentors.

St. Rupert. Isolated efforts: "Two steps forward, one back." St. Rupert was located in a low-income neighborhood in the city and, as a result, operated on a limited parish budget. Fluctuating enrollment had caused some instability in staffing, as teachers were often moved between grade levels and subject areas, as needed; some teachers even had responsibilities at both the PK–eight school and the adjacent parish high school. Before the current principal's 10-year tenure, there was extensive turnover in school administration, but steady leadership shaped the science curriculum by securing updated textbooks for grades one through seven, establishing a yearly dissection program in grades six through eight, and offering a lab-based, high school level biology course in grade eight. The principal (Ruth) had also made a consistent effort to secure grant funding to establish a technology-equipped science

lab for grades five through eight, provide science-based programs, such as a Waterbotics® competition for grade eight, and offer science-based field trips and professional development for teachers. Committed to improving measurable student learning outcomes, Principal Ruth reported elevated TerraNova standardized science test scores, which had recently averaged at about the 77th percentile. The school was also currently working toward a Blue Ribbon School designation.

St. Rupert worked from a strong commitment to serving its families and demonstrating that all students, regardless of their socioeconomic status or first language, could be academically successful. According to Principal Ruth, "I don't want [a Blue Ribbon designation] because of poverty. I want to prove that poverty or language is not a factor in education." Both the principal and teacher representative from St. Rupert described the school's efforts to recognize the strengths and potential of all students, including those who traditionally struggle in school. While the participants at St. Rupert both reported a commitment to serving their students through rigorous academic programs, data suggest that the school still lacked a coherent school-wide plan for science.

When discussing school-wide efforts to build science capacity, Principal Ruth talked mostly about a singular focus on measurable student outcomes and a specific goal of making continuous improvement on test scores. She described spending considerable time analyzing standardized test scores:

> I do a longitudinal study and I follow our [students] as they move through our school, for every subject . . . and questioning why. Is it the teacher? Or is it the instruction? What is our weakness? What's holding us back? Then I also do a latitudinal study. And in this latitudinal study, I look at the class over five years . . . Only when you have both of these [longitudinal and latitudinal studies], can you really say, this is what's going on.

Through this process, Principal Ruth aimed to get the school to the next level, pushing faculty members to share in this goal of improving test scores. During her tenure as principal, there had been steady improvements, but she was never satisfied, recounting when science test scores were averaging in the 69th national percentile:

> I said [to the teachers], no you've got to be here [at a higher level]. So

now we're at 70 and 75 [percentile]. Well, they're still hearing it. No you've got to go here [at a higher percentile] because . . . you've always got to go to the next level. That's a biggie.

While the principal spoke about this school-wide focus on improvement in positive terms, it was not necessarily perceived as such by the teachers. Rachel described the pressure she felt when she joined the staff as the middle-grade science teacher, saying, "[In the school] there's this whole thing about, can you match the standards of the previous teacher? That put a lot of pressure on me. I was a little afraid to go beyond just working with my own classes." Indeed, test scores drove much of the decision making at the school, such as determining which topics students would focus on in their science fair projects each year and how teacher performance was evaluated.

As part of her school improvement effort, Principal Ruth brought faculty groups into the conversation about their students' performance, using test scores as part of her dialogue with teachers about future goals. During these meetings, the principal instructed the teachers to focus on success and what was working as way to encourage them to share ideas and strategies, which she hoped would lead to increased collaboration:

> Too often, all [administrators] do is go to the negative [things teachers are doing]. But if you're listening to all the science teachers and they're talking about a strategy that was successful, all of the sudden you hear [them say], "I could do that! You just gave me a great idea!" And now [the teachers] have to change [their practice] . . . but this starts to happen.

Even with these isolated efforts to promote collaboration, the science teacher leader, Rachel, described limited instances of teacher collaboration with regard to science, saying, "Everybody's kind of trying to just keep things going."

St. Stephen. Turning the corner: "It's been a process of rebuilding." St. Stephen was located approximately 30 miles outside of the city and had recently undergone significant restructuring. Four years ago, the school was consolidated with three other nearby parish schools to form a consortium consisting of one regional middle school (grades six through eight), with three affiliated PK through five elementary feeder schools. This restructuring resulted in the loss of St. Stephen's middle school and approximately one third of school's total enrollment. Multiple staff layoffs and teacher reassignments to different grade levels ensued. St. Stephen's principal (Sharon) had

been at the school for the past four years since the restructuring occurred, but she was currently in a unique position in that she was serving as principal of two of the consortium elementary schools, spending half the day at each school. Despite these changes in structure and leadership, the school continuously had strong performance on the TerraNova standardized science test, and was one of the first in the Archdiocese to consistently implement the inquiry-based curriculum units in grades PK through five. St. Stephen worked with limited funds and technology-related resources (i.e., no computer teacher, families without Internet access at home) to implement this curriculum; however, the income level of families made the school eligible for grant funding to provide some science-based programs, field trips, and professional development.

In the midst of recovering from an unsettling period following their transition to the new consortium structure, St. Stephen had had significant obstacles to overcome. Principal Sharon recalled:

> The first year and into the second year, there were a lot of problems with the school [reputation] because of what was out there on Facebook. People who left were so unhappy with the transition that the things they wrote up there weren't good. . . . So that . . . was very difficult. It was very hard. But I don't hear much of that anymore.

Principal Sharon had worked hard to rebuild the school's reputation, and while she felt that she had "change[d] the message" about St. Stephen, challenges continued to arise. For example, while overall the consortium afforded the small school benefits that would not otherwise be possible—such as opportunities to collaborate and share resources—the teachers voiced some drawbacks to being part of the larger group. For instance, teachers described having an interest in establishing a school-wide focus on science, but shared that at times the school was "extra hands-tied" (Sue) when it came to making decisions because they must be approved by the whole consortium. This model limited the science-related professional development the principal could provide for the school, unless the entire consortium agreed to make that a collective priority. According to Sue, "Sometimes we do stuff without other [schools], but I think that [the principals mostly] have to make the decisions for what they think is best for all four schools," which the teachers felt limited the schools' autonomy and sometimes failed to recognize the individual needs of each school.

Despite these ongoing challenges, both the principal and teachers suggested that the school had turned a corner. "This year's our strongest year in a long time," said Sue. Sandra agreed, "It is. We've gone through some big changes. This year is, I think it's probably, truly our best." When asked what has helped change the culture, all participants highlighted how accountability and teacher collegiality had benefitted the school. For example, Sarah summarized, "I think all teachers are [collegial] in this school. They respect everyone. They are accountable for their actions, for their teaching, for what they're doing in their classroom." The principal and teachers also considered one of their strengths to be their ability to promote rigorous and meaningful science instruction throughout the entire school, mainly through the adoption of the Archdiocese's science inquiry units for the elementary grades. For example, Sue said:

> I think because Sandra starts [teaching science this way] in kindergarten, and [the students are] excited in kindergarten about science, and they're engaged in kindergarten, there's never that point then in their science education where it's boring or uninteresting to them. So where [learning] gets stagnant in third, fourth, and fifth grade, which is where testing scores usually start showing poor science scores, [the students are] not stagnant because they're excited, they're interested [in science].

While the switch to the inquiry-based units from a more traditional text-based approach had been embraced more quickly by some teachers than others, all participants discussed the continued emphasis on promoting these units across all grades, speaking to the value of having a coherent school model for science teaching and learning.

School Science Improvement Journeys

Although all four participant schools were experiencing degrees of success, none of the schools was complacent. Considering the four schools on a "journey" to school science improvement (Hallinger & Heck, 2011, p. 1; Jackson, 2000, p. 61), this section reports on ways that elements of the school science capacity framework interacted to support, and at other times constrain, school science improvement efforts. None of the elements of the model was isolated; rather, findings demonstrated how they were interacting in unique ways given the specific context and culture of the school. First, we examine

interaction of the elements of the school science capacity model in the cases of St. Stephen and St. Rupert, two schools leveraging strengths to overcome challenges, followed by an analysis of the cases of St. Anna and St. Natalia, two schools working to create communities of learners.

Leveraging strengths to overcome challenges. Evidence collected from St. Stephen and St. Rupert indicated that although these two schools had various challenges to overcome, there were areas of strength that had been, and could continue to be, leveraged. St. Stephen leveraged its organizational and social capital, even in the face of challenges brought on by restructuring the school. As evidence of the supportive, spiraling relationship between these interacting elements, the school's strengthened organizational and social capital in turn helped St. Stephen enhance the areas of intellectual capital and instructional strategies. In a contrasting example, the lack of significant interaction our analysis found between aspects of the framework at St. Rupert may have constrained the school's improvement efforts. Even though we identified areas of strength, findings illustrated that these areas may have been less valuable when they were isolated from, rather than interacting with, other areas.

First, demonstrating the intersection of organizational and social capital at St. Stephen, a benefit of the re-organization at this school turned out to be the opportunity to identify faculty who were a good match for the school. Principal Sharon recalled:

> People who aren't good team members don't stay working with me very long because [team work is] real important, because it affects everything. It permeates your whole environment. The whole school staff has to be a team, and if you have somebody in there who's causing a problem, they're just not a good fit for here.

Participants described the staffing decisions forced upon the school due to the restructuring as paying off in the long run. When asked to describe the current professional interactions at St. Stephen, Sue shared, "I think [the teachers are] all very close and we all expect everyone to pull their own weight," to which Sarah agreed, saying, "I think so too. I think there's respect here." Principal Sharon shared a similar view in saying, "I think [teachers] relate to each other more as extended family. I think they have a wonderful respect for each other." This is an example of strong leadership helping to overcome challenges by focusing on investing in relationships within the

school. Findings indicated that this respect and cohesion among the St. Stephen staff in turn strengthened the school's intellectual capital. Although there was not much time or funding for science professional development, teachers were important resources for one another. For instance, a former science teacher leader who implemented the inquiry-based units for two years prior to retiring was particularly influential in bringing the new curriculum to the school, and in bringing other teachers who were more reluctant on board. Additional intersections between organizational, social, and intellectual capital and instructional strategies were identified beyond the walls of St. Stephen. For example, teachers noted the principal's efforts to ensure that—especially given the school's small size—they had others to collaborate with across the consortium schools:

> When the [science inquiry] units were first written, we had a lot of meetings with other area schools, so that we could have large round table discussions with other third grade teachers, other kindergarten teachers . . . And have brainstorming time, because [at St. Stephen] we don't have anyone here to talk to [at the same grade level]. (Sandra)

These opportunities for collaboration represented forms of professional development, which gave teachers the potential to enhance the consistency and rigor of the school's instructional practices. Together, leveraging and continuing to further develop existing strengths allowed St. Stephen to maintain a strong science program despite limited resources and a constraining organizational structure.

In a contrasting case, findings did not indicate that St. Rupert benefited from interactions between the three forms of capital. Rather, strengths in any one form of capital were more isolated and thus constrained what might potentially be accomplished. While relationship building was clearly a priority at St. Stephen, it was less so at St. Rupert. Evidence indicated a more isolated, competitive work environment, at least with regard to science. Even though the principal made efforts to bring faculty groups together to discuss student progress and instructional approaches, it was not clear that faculty continued the collaborations outside of these formalized meetings. This was exemplified in Rachel's descriptions of the pressure she felt after joining the staff as a first year teacher. Rather than feeling supported and respected by her fellow teachers, Rachel was nervous that a veteran teacher would find out if "I hadn't done [a lesson] the way [the previous middle grade science teach-

er] did; I was getting flack for that." Science was not her area of expertise, but rather than benefiting from working collaboratively with others in her school, all the professional development that Rachel described (e.g., national conferences, local workshops) was pursued on her own. Even when she sought help from teachers in the partnering high school, it was not apparent that this new knowledge was shared within St. Rupert, or that there were any mechanisms made available to do so. Rachel explained that her leadership initiatives were primarily limited to organizing instructional resources for colleagues. She did not lead any sort of study teams, even though much of the school's teaching staff was early in their careers, had not shown a particular interest or strength in science, and may have benefited from mentoring. In these examples, organizational, intellectual, and social capitals were isolated, and thus did not strengthen other elements of the school science capacity model.

Varying means of supporting collaborative learning communities. St. Anna and St. Natalia were both experiencing a greater degree of stability overall, yet continued to work toward further improvement, including within their science programs. Evidence of a growing professional, collaborative community of learners at these two schools illustrated the positive interaction of multiple aspects within the school science capacity framework. Data from these schools suggested that this interaction was purposefully supported by the school principals, albeit in different ways. Structures supporting social and intellectual capital at St. Anna were more informal and organic, whereas at St. Natalia they were more strategic.

The structure of St. Anna's school day supported faculty in getting to know one another and in working collaboratively to support students. For example, the principal arranged for all teachers to have a 40-minute lunch break at the same time in a common faculty lunch room, which allowed for regular communication and interaction among the staff. "We tend to see each other a lot because everyone has lunch at the same time, so they're not staggered and there is a lot of informal talk in the lunchroom," said Amy. In addition, in the intermediate grades, teachers held informal lunch meetings approximately once a month to talk about student concerns. Aaron explained, "It's nice to get all five of us [intermediate grade level teachers] together and talk about what we see with these students and how some students are changing in certain ways." The focus group also uncovered multiple examples of efforts made by St. Anna teachers to share expertise with one another. For example, Amy described how she was influenced by a former teacher at the school:

> We lived together, so she'd be working on her lesson plans for fifth grade science and so we'd collaborate a lot. She got me interested certainly . . . There was a [National Science Teacher Association] conference in Boston and she said, "You should come with me." But I said, "You know, I teach this much science a day [*gesturing to a small amount*]." But she said, "You're a science teacher! You should come with me!"

Teacher collaborations such as this one often happened organically at St. Anna, but the principal also promoted intellectual capital, for example through the annual funds she made available for teachers to pursue their own professional development opportunities. Teachers also felt that the principal's "open-door" policy encouraged them to come and discuss ideas, such as starting a science club or summer program. Concerns were raised, though, that constructive criticism was rare. "We can go to [the principal] and say, 'This is what I'd like to do', and she will try to make it happen. Very rarely do we hear, 'No.' Which is good, and bad at times too," explained Aaron. Amy agreed, saying, "Sometimes I think we could use a little kick in the butt for stuff. [The principal] says, 'You're doing great,' and sometimes I feel like she needs to say, 'Hey, you need to be doing this.'" Overall, these structures in place at St. Anna illustrated the intersections of organizational, intellectual, and social capital and were consistent with the nurturing climate of the school and its keen focus on understanding and meeting student needs.

   At St. Natalia, the principal also created structures for collaboration, but with a more specific focus on academics and pushing teachers to reach high expectations. Fitting given the transitions taking place as a result of new curricular materials, these structures were intended to support teachers in embracing the student-centered, inquiry-based approach of the new elementary and middle grade science curriculums. For example, the principal paired an accomplished veteran middle grade science teacher to team-teach with another teacher who had been less comfortable with the new science curriculum. Principal Nancy explained:

> The reason behind that [team teaching] is one of [the teachers] I think is nearing the end of her career . . . I'm hoping that she can mentor her partner who has experience teaching science, but not at this level and not this kind of science—she's a textbook science teacher. . . . [The mentor teacher has] this deep knowledge so that when she's going from table to table questioning students, [her knowledge] is deep and you

know [her questions have] that higher order thinking that asks [students] to challenge themselves a little bit. So I'm hoping exposure to [those skills] will help facilitate that with her partner as well. So I put them together deliberately for that [reason].

On a larger scale, a Teacher Assistance Team (TAT) was also created, which consisted of teachers from every grade level who came together to help support teachers with problems of practice. Principal Nancy described the TAT as a crucial initiative intended to increase communication and build trust among the teachers:

> Part of [the TAT's] responsibility is to reach out to their colleagues to identify when people are struggling. To kind of build that trust so that we [as a faculty] can come to a collaborative conversation to support [teachers] as they try to find a way to meet that child's needs.

Even when collaborative efforts came about more serendipitously from the teachers themselves, there was an effort to provide some structure. For example, during a routine meeting with fourth- through eighth-grade teachers early in the year, Principal Nancy recalled:

> Questions came up and there was real conversation from fourth and fifth grade about "We do this, this, and this to get [students] ready for you guys [in the middle school] and we expect that you're taking them to the next level." And it was a great conversation, which then has continued. I'm sort of leveraging my [assistant principal] to help challenge and drive [these conversations] a little bit . . . [to push] for a little more rigor.

These vertical conversations were then formally adopted and occurred multiple times a month. The interest in coherence across grade levels was reiterated by teachers, who all agreed that these conversations were beneficial. According to Noreen:

> [Administration] has given us a lot of time in faculty meetings to work together in groups and different group settings, which is different than in the past. So they're actually giving us the opportunity to *talk* to each other, which is important.

These examples illustrate how leadership at St. Natalia leveraged both social and intellectual capital while further encouraging the school's reflective stance toward its instructional practices. Findings indicated that intellectual capital and instructional and assessment strategies all strengthened as a result.

However, findings also revealed that relationships between the St. Natalia principal and teachers remained strained at times. Opposite the sentiment expressed by teachers at St. Anna, who felt they might become too comfortable without more constructive criticism from the principal, St. Natalia teachers desired more recognition from the administration for their efforts:

> Expectations [from the administration] are high and that's good. I feel like we [teachers] get pushed and that's good—high expectations. Personally, I'd like more encouragement or positive feedback or compliments. Because I think we all work really hard to do our best and I think we do very well. (Natalie)

These two examples further illustrated the interactive nature of the elements of the school science capacity model, as well as challenges that come with trying to balance the interactions of these elements.

Discussion

Case studies of the four urban Catholic grade schools presented in this article contribute to a more nuanced understanding of the school science capacity model depicted in Figure 1. However, while the two-dimensional model shows a static phenomenon, it is well understood that the work of schools is inherently dynamic and complex (Davis & Sumara, 2008). First, the complexity of the process of school science capacity building was reinforced by examining schools with similar elements in the model—such as a commonly shared moral purpose to work as a community to educate all of the children attending their schools, no matter their background or needs—and illustrating how the context and culture of these schools influenced the way their common mission was carried out. For example, St. Anna focused efforts on providing enrichment programs to enhance the development of the whole child, while St. Rupert placed heavy emphasis on identifying weaknesses in test scores and working to close gaps among grade levels and student populations.

Second, findings indicated that each aspect of the model was in flux as each school worked to build science capacity. Improvements within any given area were considered part of a continuous process of responding to arising challenges and resisting complacency. This provided additional evidence that the model is irreducible; individual elements themselves were not as telling as the interactions between the elements. This further supports the understanding of the model as a complex network of elements wherein each component participates in the transformation of other components. For instance, while the presence of one or more areas of strength might be deemed positive, findings from cross-case analyses indicated that isolated strengths may not have necessarily proven beneficial. Rather, we found the greatest benefits in the interactions of elements, allowing for strengths in individual areas to leverage assets within other areas in a spiraling, mutually reinforcing relationship. This dynamic was apparent at St. Stephen, for example, where data analysis indicated that multiple forms of capital—organizational, social, and intellectual—mutually interacted and with instructional strategies to reinforce and further strengthen one another, even in the face of challenges from recent restructuring of the school. Simultaneously, findings indicated the need to maintain a healthy balance within the interactions of model elements as what might serve as a support in one respect can be a constraint in another. For example, in considering differences in principal-teacher relationships at St. Anna and St. Natalia, teachers critiqued their principal for providing both too much and too little support and encouragement for their work.

Finally, realizations about both the unique ways elements of the model were leveraged to take action and the importance of the interactions between elements over the individual elements themselves reinforce the significance of taking an asset-based approach when studying schools as organizations. Although there were some notable drawbacks associated with particular tactics to building science capacity in each school—such as St. Rupert's narrow focus on test scores, or St. Natalia's decision-making without considerable teacher input—successful unique interactions among other elements of the model show multiple paths to improvement despite these imperfections. It would have been easy to inaccurately label participant schools as "struggling" or "successful" based on a simple checklist of what individual elements of the model were present and at what level. However, upon deeper analysis of where and how elements interacted, and the consequences of those interactions, we realized some of these participant schools' greatest strengths and challenges. Examining four distinct cases of schools all working to achieve

their moral purpose and build school science capacity—albeit in different ways that leveraged aspects of their unique contexts and cultures—reinforced the need to approach the model of school science capacity as a dynamic representation to aid in the analysis of complex systems, rather than as a static list of elements that should be present in schools.

Implications

It has been lamented that "Catholic education has been treated as either a special topic or selective context on or in which other research has been conducted" (Frabutt et al., 2013, p. 76). The current study contributes to the field of Catholic education by highlighting the work of Catholic schools to build science capacity and by informing practitioners of how they might accomplish this work in their own unique settings. Even though this case study is purposefully limited in scope, implications can be drawn for schools assessing and working toward school improvement.

This study's findings reinforce an increasing recognition of the importance of the social context of school (Schneider, 2005). Accumulating evidence indicates that leadership and professional environments have indirect effects on improved instruction and student achievement (Louis et al., 2010), which speaks to the importance of examining cases of professional communities that embody shared values, a common focus on student learning, collaboration around developing curriculum, and the purposeful sharing of instructional practices (Louis et al., 2010). This study affirms that schools can foster this type of professional community by seeking strong leadership around instruction and student learning, collective and shared work around school decision-making, and positive interpersonal relationships. Further, schools focused on improvement efforts will recognize these elements as integrated rather than isolated. School cases in this study also illustrate that this process of improvement is not necessarily linear, and so schools must be comfortable with making progress at times, and taking a step back at others.

The current study also revealed that a singular focus on improving test scores may come at the expense of supporting relationship-building and developing commitment to a common goal and purpose, which serve as a crucial foundation for the work of educating students. Conversely, collaborative professional communities characterized by mutual respect, opportunities for collaborative planning, peer observation, and feedback are shown to lead

to improved instructional practices, enhanced self-efficacy, and increased student achievement (Burns & Darling-Hammond, 2014). As such schools can benefit immensely by working toward building a school culture supportive of collaboration so that teachers can step out of their comfort zone and take professional risks, such as embracing a new inquiry-based approach to science instruction. The peer mentoring that occurred at several participant schools illustrates how investing in collegiality may serve as a resource for school problem-solving and fuel school science improvement efforts (Smetana et al.; Whitworth & Chiu, 2015), especially for small Catholic schools that do not always have formally defined coaching positions or other instructional support structures (Bryk et al., 1993; Dorner Spillane, & Pustejovsky, 2011).

Conclusion

Common features of Catholic schools that have been identified in the literature, including the strong sense of community, professional relationships, governance structure, and ideology (Carbonaro & Covay, 2010; DeNobile & McCormick, 2008; Frabutt et al., 2013), initially contributed to our desire to study science capacity building in these schools. Our analysis afforded deeper insight into how these unique features can actively support school science capacity building, such as a strong sense of community providing a potential wealth of social capital to be leveraged in service of school-wide science efforts. However, this research afforded more than just the identification of commonalities that distinguish Catholic schools—in terms of the values and guiding principles that provided each participant school with a collective sense of purpose and direction—as potential strengths for building school science capacity. We also reaffirmed the importance of the unique aspects of context and culture in our conceptual model. While each of the four schools demonstrated a clear commitment to meeting individual students where they were and to support and respond to the various needs and backgrounds that characterized their school population, each worked toward this mission by building school science capacity in their own manner, supporting the conclusion that there is not a single way for schools, and even Catholic schools, to succeed. We intend that this research, and specifically the understandings gleaned from teacher leader and principal accounts of building science capacity within their schools, will encourage educators seeking to make science a priority to embrace more contextualized approaches and to envision

how they might leverage existing assets while traveling their own journey of school science improvement.

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Appendix

Principal Interview and Science Teacher Leader Focus Group Protocol Alignment with the School Science Capacity Framework

Protocol Questions	Elements of the School Science Capacity Framework Addressed						
	Moral Purpose	Context	Culture	Intellectual Capital	Social Capital	Organizational Capital	Instructional & Assessment Strategies
How would describe your school's performance in science? To what would you attribute this situation? How do you feel you have contributed to your school's science achievement?	X	X		X			
Please tell us about the recent changes to your science program, including the new inquiry units. What prompted these changes? How have the changes been received?		X	X				X
In what ways do teachers collaborate on science? How much of a role does leadership have in creating such mechanisms and how much is for the teachers to decide and control? Is there any issue with individuals who choose not to participate in science collaborations?			X		X	X	
Please describe the more unique characteristics of your school population and the local community. To what extent do the ethnicity, language, and culture of your student body influence your decision-making about the school science program?	X	X			X		

Protocol Questions	Elements of the School Science Capacity Framework Addressed						
	Moral Purpose	Context	Culture	Intellectual Capital	Social Capital	Organizational Capital	Instructional & Assessment Strategies
What kinds of cooperative and reciprocal relationships exist between your school and other agencies (e.g., universities, nearby schools, other agencies)?		X		X	X		
Do you have money you can use at your discretion for supporting science teaching and learning in your school? Where do those funds come from and how do you decide how to put those to use?		X				X	
How are decisions made about science professional development? How receptive is the faculty to science professional development?			X			X	
How would you describe the norms of professional interactions within the school? What evidence do you have of trust among your faculty? What challenges are faced with maintaining a culture supportive of student science achievement?	X		X		X		
When hiring faculty and staff, what qualities do you look for? Are there any particular teacher traits you feel are specific to science? What other human resources exist that you depend upon? How do they fit into the school culture?			X	X			

Protocol Questions	Elements of the School Science Capacity Framework Addressed						
	Moral Purpose	Context	Culture	Intellectual Capital	Social Capital	Organizational Capital	Instructional & Assessment Strategies
Leadership within a school may extend beyond the formal administration. How would you characterize the distribution of leadership within your school that is specific to your science program?			X			X	
How is data used within your school: monitoring students, informing instruction, evaluating teachers, etc.? When you examine the data, what demographic factors to you take into account: ethnicity, income, English language fluency, etc.?		X					X