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Models of Providing Science Instruction in the Elementary Grades: A Research Agenda to Inform Decision Makers

This article describes the outgrowth of a recently held invitational conference, supported by the National Science Foundation, to define, describe, and examine existing models for the use of elementary science specialists. The authors explore the educational, policy, and financial issues that affect the use of science specialists as well as offer a research agenda to assess the quality and effectiveness of specialist-managed elementary science programs to ensure that students experience high-quality science teaching.

Introduction

For the past several decades, the Center for Science Education (CSE) at Education Development Center, Inc. (EDC), has worked across the United States with school districts to help them reform their elementary science education programs. Although many school districts employ some model of science specialists to deliver elementary science instruction, there currently is little research about the effectiveness of specialists in enhancing student science learning. What exists in the literature about the role and impact of science specialists is limited and focuses primarily on descriptions of various models and debates their relative merits.

Based on our experience working with school districts and the dearth of current research about the efficacy of science specialists, the CSE proposed an invitational conference to the National Science Foundation to define, describe, and examine existing models for the use of elementary science specialists; explore the educational, policy, and financial issues that affect the use of science specialists; and most importantly, develop a research agenda to assess the quality and effectiveness of specialist-managed elementary science programs on student outcomes. The assumption was that the findings from this conference would begin to add to the existing knowledge about various models of support for science learning at the elementary level and would contribute to the development of a research agenda. Our expectation was that case studies and a research agenda emanating from this conference would lead to more-informed decision making about how best to ensure adequate and appropriate science instruction in the elementary grades.

The goals of the conference were to: describe existing and past science-specialist programs, compare and contrast the elementary science programs provided by specialists vs. regular classroom teachers, identify the specific skills and knowledge that science specialists need to be effective and survey how these are reflected in existing state certification requirements, identify the elements of school culture and administrative support needed for effective science specialist programs, learn about successful training programs for the development of science specialists, and develop research questions and an agenda focused on the impact of elementary science specialists on student science outcomes.

The conference, held in the fall of 2007, brought together state science supervisors; leaders from higher education; district superintendents;

district science coordinators; MSP program coordinators and project directors; science education experts; science education consultants; school principals; literacy, mathematics, and science specialists; mentor teachers; elementary classroom teachers; researchers; and evaluators to share and reflect upon the current use of specialists, their contributions to elementary science teaching, and their effectiveness in supporting students' science learning. Following the conference, manuscripts were analyzed and three products were developed: a research agenda, case studies of different specialist models, and conference proceedings.

Need for Creating a Research Agenda

The 2007-2008 school year marked the beginning of a new era in science education as the federal government, beneath No Child Left Behind, began holding states accountable for student performance in science. Accordingly, states are beginning to ramp up their investment in and attention to science education. The timing is critical; international comparisons of student performance, such as Trends in International Mathematics and Science Study, highlight the fact that American students continue to lag behind other industrialized nations in math and the sciences despite 15 years of education reform (National Center for Education Statistics, 2003). The lack of achievement in science and mathematics education in the United States has resulted in a situation where many students do not have the knowledge and skills to adequately prepare them for the workforce or postsecondary education. In fact, a recent study by the National Science Board (2007) found that 20 percent of entering college students must take remedial science and mathematics courses. Moreover, the ability to respond to major public policy issues, such as global warming and the energy crisis, is dependent upon a "scientifically literate" citizenry being able to understand and evaluate scientific issues (National Research Council, 2007b; 2007a). Thus, it is crucial that American students receive high-quality science instruction and that our scarce energy and resources are directed to the levers that will have the greatest impact on student achievement.

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Despite this new sense of urgency, it is not the first time that national attention has turned to reforming science education. In fact, science education reforms are cyclical, with prior reform efforts, such as the current emphasis on "inquiry," coming in and out of vogue over the years depending upon social and economic factors. National attention is drawn to science education when it is perceived as relevant to the society as a whole, such as after a breakthrough (seen after WWII) or due to a perceived threat (during the Space Race after the Soviet Union launched Sputnik) (NRC 2007b, 2007a; Atkins & Black, 2007; Business Higher Education Forum, 2007). In fact, the post-WWII/Cold War era of the 1950s and 1960s marks the beginning of United States government investment in "modernizing the curriculum" and teacher professional development (Atkins & Black, 2007; NRC, 2007b).

The current period of standards-based reform and testing in science education is no different from prior attempts. It is becoming increasingly clear that the STEM disciplines (science, technology, engineering, and math) will be important for a scientifically literate citizenry and the future economic competitiveness of the nation (NRC, 2007a). Though the vast majority of reform efforts have been directed toward the secondary level, the philosophical approach to the discipline, as well as the significance of the topic, has often trickled down to elementary schools. Most recently, in the 1990s, Project 2061's *Benchmarks for Science Literacy* (American Associate for the Advancement of Science, 1993) and National Research Council's *National Science Education Standards* (1996) promoted national benchmarks for science instruction. Both espoused an inquiry-oriented teaching approach in which students are actively involved in scientific investigations, engaged in hands-on activities, asking questions, and finding answers as opposed to the more traditional approach of learning a random assortment of facts from a textbook (Schwartz, 2000; Jones & Edmunds, 2006; Atkins & Black, 2007).

Despite an emphasis upon raising standards, it is apparent No Child Left Behind has placed science on the backburner in the face of other curricular demands, particularly at the elementary level (Sandler, 2003). Early emphasis upon reading and mathematics skills has resulted in less time, energy, and resources being dedicated to science instruction. In fact, recent reports show that 44 percent of districts across the country have cut the amount of instructional time for science in elementary schools (McMurrer, 2007). Moreover, increasing pressures in other disciplines has also resulted in a wide variation in the quality of the science that *is* taught (McMurrer, 2008).

Prior attempts at science education reform have made it clear that, to be fully effective, reform efforts must begin in elementary school. Evidence indicates that students who start in secondary school, having had limited exposure in the early years, rarely make learning gains equal to those who had a solid science foundation in the elementary years (Nelson & Landel, 2007). Despite the fact that the *National Science Education Standards* recommend the use of inquiry as part of the instructional strategies used to teach science, we also know that elementary teachers are largely unprepared and uncomfortable with teaching in this way, because "this envisioned approach is vastly different from the more traditional teaching approach many elementary teachers experienced themselves …" (Schwartz, 2000, p. 1). Furthermore, the recent focus upon standards and testing has created a tension between the knowledge and skills that are seen as valuable, which are difficult to assess, and what can be easily tested. This makes setting priorities in elementary science instruction with limited resources and time even more difficult to determine (Schwartz, 2000). As a result, inquiry-based science teaching is not the instructional norm at the elementary level.

Despite all of these challenges facing science in elementary schools, the importance of investing in teachers is apparent. Two recent national studies clearly defined the pivotal role teachers—and excellent teaching—play in student achievement. The Business Higher Education Forum found that "the quality of P-12 mathematics and science teaching is the single most important factor in improving student mathematics and science learning" (2007, p. 2). In their report, the National Research Council outlines the hallmarks of teacher excellence as "thorough knowledge of content, solid pedagogical skills, motivational abilities, and career-long opportunities for continuing education" (2007a, p. 113). Thus, investing in teachers and teaching and building teachers' confidence and competence with the discipline will be crucial to improving student achievement at the elementary level.

Compounding this inattention to elementary science is the tendency of elementary teachers to prefer non-science subjects. This has had a number of effects on science teaching that have been consistently documented over many years, including teachers' having limited science content knowledge—particularly in the physical sciences, low confidence to teach science, and the perception that science is a body of facts and knowledge (Abell & Roth, 1992; Australian Foundation for Science, 1991; Department of Education, Employment and Training, 1989; Harlen, 1997).

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Constraints to elementary teachers on teaching science include the following: insufficient content knowledge, lack of time, inadequate materials and facilities, competing curricular priorities, lack of support in school (largely from administration), and minimal sense of self-efficacy in science (Schwartz, 2000; Gess-Newsome, 1999; Rhoton, Field, & Prather, 1992):

One can think of these constraints to teaching science in elementary schools as falling into two main categories: school level support and the capacity of teachers. It is clear that any attempt to reform science in elementary school must remove these school-level barriers to effective science instruction and boost the pedagogical skills, content knowledge, and confidence of elementary teachers in the sciences.

Needless to say, accomplishing these goals is easier said than done. One of the biggest obstacles to education reform has been that policy makers have grossly underestimated the investment of time and resources necessary to change practice at scale. A recent study by Nelson and Landel (2007) shows that more than 80 hours of professional development is needed to effectively teach inquiry-based science at the elementary level. Unfortunately, this study also found that few elementary schools invest in professional development to ensure that the curriculum adopted by the school is implemented adequately. As a result, only 18 percent of elementary science and math teachers' lesson plans were found to exhibit "elements of effective science and mathematics instruction" (Weiss, quoted in Nelson & Landel, 2007, p. 73).

Furthermore, data from the Horizon Research, Inc., evaluations of the early Local Systemic Change projects (LSCs) suggest that even with significant teacher professional development (100 plus hours), the quality of instruction is in question. “While limited, our analysis of the data seems to indicate that despite the 100+ hours of sustained and in-depth professional development each teacher received, science instruction delivered by elementary classroom teachers was not adequate” (Weiss, 2001). In addition, the biggest concern of teachers in the LSCs is that they were not getting enough support. While teachers had been trained to use the inquiry-based curriculum materials, they had difficulty translating what they had experienced in professional development sessions to their classrooms. They indicated that they needed more in-classroom help. More specifically, a CPRE report on the results of six years of in-depth professional development with elementary teachers by the Merck Institute for Science Education states that “given the limited effects of the initiative on student achievement to date, the unevenness of science knowledge among elementary science teachers, and the anticipated difficulties in sustaining their participation over time, it makes sense to consider using science specialists to teach science in grades 2-4” (Consortium for Policy Research in Education, 1999, Experimenting with the Use of Science Specialists section, para. 1).

The centrality of providing support to science teachers at all levels to reach NCLB requirements is now being acknowledged. At the recent Massachusetts STEM Summit (October 17, 2005), Congressman Vernon Ehlers of Michigan remarked that good science education should include good support mechanisms and that there should be at least one experienced go-to person in a school building. In the United States, approximately 15 percent of elementary students receive science instruction from a science specialist in addition to their regular teachers, and another 12 percent receive science instruction from a science specialist instead of their regular classroom teachers (Weiss, Banilower, McMahon & Smith, 2001).

Prior attempts at science education reform have made it clear that, to be fully effective, reform efforts must begin in elementary school.

While the use of a specialist model ensures that science is taught, there is little known about the quality of instruction or the impact on students’ science learning. Perceived ability to deliver effective science teaching has been shown to be associated with elaborate science content knowledge (Ramsey-Gassert, Shroyer, & Staver, 1996; Shrigley, 1977), successful science teaching experiences (Dickinson, Burns, Hagen, & Locker, 1997; Shrigley, 1977; Tilgner, 1990), and a commitment to elementary science instruction (Ramsey-Gassert et al., 1996).

Given the importance of improving science teaching at the elementary level and the many significant difficulties associated with changing classroom teachers’ science instruction, one approach has been to turn to the role of science specialist as a school’s primary source of science leadership, teaching, and/or support. Unfortunately, little research exists that indicates whether this approach will have an effect on science instruction and student achievement (Schwartz, 2000). As a consequence, school and district leaders are investing scarce resources in a strategy about which little is known and upon which much depends.

This research agenda will map the territory surrounding the topic of elementary science specialists in a systematic way in order to amass knowledge and to make informed choices to ensure that elementary students experience high-quality science teaching.

Purpose for This Research Agenda

This research agenda is intended to serve decision makers, policy makers, researchers, funders, and practitioners by providing them with an understanding of the areas of research that need to be explored, and within each area, what specific topics should be investigated. This research is becoming increasingly relevant and useful as “specialists” have entered the national- and state-level dialogue for the improvement of science teaching. In individual states, attention has been given to the role of specialist as a way to enhance science leadership at the district and school levels, including a master’s degree program for science specialists in Ohio and a certificate of endorsement for teacher leaders in math and science in Kentucky (Education Development Center, Inc., 2008). This agenda provides a map of the issues associated with elementary science teaching and learning that need to be explored and understood, their complexities, and how they are inter-related. It offers a structured research program that is a starting place for further comment and clarification.

Finally, it offers funders of research an overview of the breadth and depth of work that is needed to inform their short- and long-term funding decisions and to provide an overview of how individual studies will build a comprehensive understanding.

This research agenda will not focus on issues related to appropriate methodologies, research designs, and rigor. It will focus on elaborating the depth and breadth of issues relating to the implementation and impact of elementary science specialist models. Conference attendees have identified the issues, highlighted the nature of the questions that they believe must be addressed, and organized them in a framework that will, we hope, enable more reflection and refinement, and, ultimately, advance the progress of relevant research and its utilization by decision makers.

Current Status of Research: What Do We Know About Science Specialists?

Despite a large number of articles addressing the topic of elementary specialists in the literature, there is a dearth of research taking a rigorous approach to studying the efficacy and implementation of science specialists in elementary schools (Gess-Newsome, 1999; Schwartz, 2000). Most of the literature approaches the subject from the philosophical or descriptive level, with little empirical value or in-depth analysis (Jones & Edmunds, 2006). In fact, a literature review of the topic of elementary science specialists found 14 articles that address the topic, but only two studies, Schwartz (2000) and Jones and Edmunds (2006), can be considered rigorous research studies, defined as having a specific research question in which data is collected and analyzed in such a way as to answer the initial research question.

Schwartz (2000) offers the sole empirical evaluation of the effectiveness of specialists compared with classroom teachers. This study compares teachers and students in a district with elementary science specialists to a district following the more traditional, classroom teacher model. The so-called “specialist district” utilizes a model in which the science specialist is responsible for all of the planning and instruction in science. The classroom teacher serves as a facilitator during the lesson and is responsible for follow-up during regular class time. Each class meets for science with the specialist teacher twice a week because the specialist is responsible for teaching all science courses in the elementary school for fourth through sixth grades. The evaluation was based upon (1) a survey of teacher views and opinions regarding science education; (2) sample lesson plans submitted by the teachers to address specific topics at each grade level that were analyzed for the alignment of teaching goals to the National Research Council (1996) and AAAS (1993) standards; (3) student performance on state assessments; and (4) samples of student work from classroom activities.

The evaluation found that specialists held a view of science instruction that was more consistent with the current reform agenda in science education (i.e., emphasis on problem solving and thinking skills vs. traditional textbook-based instruction). Though classroom teachers also claimed to espouse the inquiry approach to science education in the survey, the analysis of lesson plans revealed that classroom teacher beliefs about inquiry captured in the survey did not transfer to classroom plans for instruction. Overall, the lesson plans of the classroom teachers were much more factual and text-book-based with little time for students to creatively explore the answers to problems. On the other hand, the specialists’ lesson plans maintained a focus upon building student problem-solving and critical-thinking skills. For example, as noted in the survey by one specialist, “in this student-centered teaching model, independent activities are designed to support the concepts being taught, while students are responsible for constructing their own understanding of the concepts” (Schwartz, 2000, p. 7).

An analysis of student test scores on the state standardized assessments for fourth through sixth grade science found no significant difference in student performance between the specialist district and the traditional district. However, Schwartz (2000) points out an important caveat: standardized exams currently only test student mastery of lower-level knowledge and comprehension. It is for this reason that samples of classroom work were collected and analyzed for evidence of student thinking.[1] Evidence was found in student work to support the fact that higher-order-thinking skills were taught. For instance, students were able to find a relationship between laboratory results and the original research question. Thus, in addition to building the higher-order-thinking and inquiry skills, specialists are still able to prepare students equally well as classroom teachers for the base knowledge targeted in standardized tests.

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[1] These data were only collected in the specialist district due to limitations in access to the control district.

Schwartz concluded that, "students taught by the science specialists (a) were engaged in open-ended, inquiry-oriented, science-based activities of the kind often advocated, but mostly absent, in elementary school, and (b) demonstrated problem solving and higher order and critical thinking skills" (2000, p. 1). This result implies that change/reform is more likely in the hands of specialists; it takes a highly skilled professional—in both content and pedagogy—to make this type of science (inquiry, hands-on) happen in the elementary science classroom.

Though these findings strongly indicate that science specialists are more effective instructors of inquiry-based science, it is important to note that Schwartz emphasizes the context dependence of these findings. The specialist district in this analysis utilized one specific model: the specialist was primarily responsible for classroom instruction with students. Schwartz suggests that the specialist may assume other responsibilities aside from teaching itself, including providing professional development to other teachers. This may be a cost effective in-house alternative for professional development and, in turn, could have a more transformative effect on the instructional methods of classroom teachers and lead to the improvement of the school science program as a whole. However, this was beyond the scope of the analysis, and no evaluations of alternative models were explored.

The second rigorous study by Jones and Edmunds (2006) was based on the variation in the implementation of the specialist model at the school level. Jones and Edmunds found most articles dealing with the topic from the philosophical role alone. Through school and classroom observations, interviews with teachers and administrators, and teacher surveys, they compared the three basic models for science instruction in elementary schools, defined as:

1. *classroom teacher model:* the basic model for instruction in which one teacher is responsible for teaching all subjects in a self-contained classroom
2. *science resource model:* the specialist provides technical assistance to the classroom teacher who maintains primary responsibility for instruction
3. *science instructor model:* one individual is hired specifically to teach science across a variety of grade levels

Similar to the study by Schwartz, Jones and Edmunds (2006) found that the instruction of the specialists is more closely aligned with the new standards for science instruction; students are engaged in more open-ended and "creative" exploration of science concepts and content. Additionally, Jones and Edmunds found that in schools with a science specialist, regardless of the specific model used, more attention was given to science in the school through labs, activities, more materials and resources, or prominently displayed student work. "Specialists in the school, in whatever discipline, may result in an increased physical presence of that discipline in the school" (p. 334). This study also showed that schools with science resource teachers dedicate more instructional time to harder-to-teach topics like physical science. Moreover, teachers displayed a greater interest in science and increased involvement in professional development and improving their own science knowledge and instructional practice. The study concluded that this increased dedication at the school level may alleviate the competing demands made on teachers at the elementary level and facilitate consistent high-quality instruction in science.

Gaps in the Research and Our Understandings

These two aforementioned studies suggest that science specialists are both more comfortable and better able to engage students in open-ended inquiry and problem solving. However, there are many factors that need to be taken into consideration, regarding both the generalizability of these results and their applicability to the school context. The varying models of implementation are largely due to the fact that there are many variations on how science instruction is delivered to students at the elementary level depending on local staffing and budgeting restraints (Jones & Edmunds, 2006). All of the studies, though they provide important initial information, are context dependent. Each school system—and school for that matter—has adapted the role of specialist to their specific context and needs. Thus, there is no consensus on the exact responsibilities a specialist should have with respect to teachers and students, or to the school's science program.

Furthermore, because there is no clear, widely accepted definition of an "elementary science specialist" or the role they should serve in the school, the specific characteristics and, thus, qualifications that will make them most effective are unknown. Jones and Edmunds (2006) and Schwartz (2000) both touch upon this issue. This has implications for the preparation and certification of specialists. Schwartz (2000) noted that science specialists are able to be more innovative and effective because they have a stronger science background than the average classroom science teacher. The importance of content knowledge for inquiry teaching is well documented (Dobey & Shafer, 1984; Ramsey-Gassert, 1996; Shirgley, 1977), and specialists tend to be hired because they have more content knowledge (Gess-Newsome, 1999; Schwartz, 2000). But, in addition to content knowledge, what other skills and knowledge does a specialist need to be qualified for this position? Should leadership be a component of training? This must be worked out before the impact of specialists on teacher practice, student learning, and system of science instruction can be routinely evaluated. At this point, there are more questions than answers. Still, the field knows a lot about science instruction, and this knowledge will have a bearing on the future of elementary science programs and how research on elementary science specialists progresses.

What the Field Believes Is True

According to the National Research Council's *National Science Education Standards* (1996), this new vision of science teaching "requires integrating knowledge of science, learning, pedagogy, and students; it also requires applying that knowledge to science teaching" (p. 62). Gess-Newsome (1999) deconstructed this statement and outlined the four teacher attributes that are important to teaching science well: content knowledge and attitudes, pedagogical knowledge, knowledge of students and knowledge of curriculum. Few elementary teachers have high knowledge and skills in each of these areas and, perhaps, it is unreasonable to expect that elementary teachers be experts in all content areas.

While the use of a specialist model ensures that science is taught, there is little known about the quality of instruction or the impact on students' science learning.

The field believes that science specialists possess the attributes identified by Gess-Newsome, and therefore offer a way of providing better science instruction. Aside from the two research studies outlined above, all but one of the remaining articles concerning elementary specialists are descriptive or anecdotal accounts of a specialist-type model in one specific school or district (Century & St. John, n.d.; Nelson & Landel, 2007; Mangiante, 2006; Jacobson, 2004; Rhoton et al.,1992). These articles propose some form of a science specialist, whether it is an individual or a team approach, as a solution to the barriers to providing high-quality science instruction in the elementary grades.

Existing programs for teaching science at the elementary level fall into four categories or models: (1) classroom teachers are responsible for teaching science; (2) classroom-based science specialists with their own regular classrooms provide resources and support for other classroom teachers; (3) school-based science specialists provide direct instruction to students within or across grade levels; and (4) district-based science specialists serve as a resource and support to classroom teachers in several schools. In addition, mentoring, a more and more visible professional development strategy, may take place within several of these categories. With the pressure of NCLB and renewed interest in science, the question of how and to what degree the different models and the programs within them affect student outcomes becomes critical.

Several case studies offer anecdotal descriptions of these models in practice. Jacobson (2004) described how having a science specialist in the school in the role of resource teacher ensured that hands-on science was still able to occur with budget cuts and increasing curricular demands. "Specialists reinforce the science lessons taught by regular teachers by conducting experiments that too often get dropped because of a crowded school day" (p. 15). Mangiante (2006) describes an in-house model for professional development in which the science specialist and classroom teacher are co-teachers. In this model, the classroom teacher learns from the specialist by learning alongside his or her students. Mangiante found that this was "empowering" to classroom teachers attempting to teach science and reduced some of the confidence issues associated with teaching inquiry-based science.

All of these articles acknowledge some of the challenges in implementing a version of the specialist model at the school level, particularly in the resource model. Mangiante (2006) recognizes that oftentimes the specialist serves the role of an "itinerant teacher," providing off periods for classroom teachers. Science educators, such as Karen Worth (quoted in Jacobson, 2004), worries that in this specialist model, science is "falling off the back burner" by being treated as separate;

too often, collaboration does not happen between the classroom teacher and the specialist.

Furthermore, a recurring theme among these anecdotal articles is the importance of context for the effectiveness of the model. Rhoton et al. (1992) outlines the negative effect school-level structures can have on science programs. This article highlights the fact that "teacher initiated change" and teacher ownership of the initiative, which is often touted as a strength of the specialist program, is not enough. Principal involvement is essential for the improvement of any science program and describes an innovative twist on a specialist model, implemented at the district level, in which a classroom teacher and the school principal are trained together in the specialist program to invest in "instructional skills, administrative insights, and content knowledge" (p. 17).

In general, these descriptive articles emphasize several important points:

1. Science specialists can be school-level science experts, and their knowledge and experience can be used in a variety of ways to meet the financial and logistical needs of the school or district.
2. Specialists can be an excellent resource for professional development if school structures are established to facilitate communication and observation.
3. Principal involvement is crucial, and school structures need to be in place to support the work and influence of the teacher-initiated change.
4. Treating science as separate from the rest of the curriculum in the elementary grades may be a mistake, particularly if connections are not made across the curriculum. There is also evidence that classroom teachers (Schwartz, 2000) feel even more inferior and teach even less science than if there were no specialist in the school. It is not a good thing if only one person holds the knowledge; this knowledge must be shared with others and connected to what students are learning in other courses.

But, in a time of competing curricular demands at the elementary level, rising stakes for science, and financial cuts, the field must provide best practices to guide the decision-making efforts of elementary schools to improve their science instruction.

The need for creating a research agenda to assess the impact of the science specialist is long overdue. While there has been a considerable amount of research verifying the need for science specialists, there has been little research that focuses specifically on the role and impact of science specialists in improving student achievement.

Research Questions

In the National Research Council's book *Scientific Research in Education* (2002), Shavelson and Towne identify three basic and interrelated lines of investigation into which most research questions fall: "Description—what is happening? Cause—is there a systematic effect? And process or mechanism—why or how is it happening?" (p. 99). This categorization of research questions offers us a useful framework for the research agenda developed to investigate the nature and impact of the elementary science specialist. Although these lines of investigation explore different questions, Shavelson and Towne note their close relationship to one another, and we echo that observation here. We have divided the investigations that research should undertake into these three categories for the sake of clarity; however, we acknowledge that it is a somewhat artificial separation. The research questions that we raise below can be viewed from different perspectives and investigated in a variety of combinations and designs.

Description— What Is Happening?

Conference attendees acknowledged the wide variation in models for deploying science specialists in elementary schools, and at the same time categorized them into variations of two major groups: teacher mentoring model and student instructional model.

Four case studies of specialist models implemented in diverse U.S. districts were generated from the conference. These are only examples of the variation that exists in the design of a science specialist's role. As conference participants explained, there is considerable variation in the ways these models are implemented. Before we can understand anything about the impact of any given science specialist model, we need to know what these models are. Descriptive studies are needed that systematically document and describe *what* particular models are being implemented within the mentoring and instructional models, their particular components, and how they function.

Conference participants identified three areas that comprise the mentoring or instructional science specialist models: (1) the role of the specialists, (2) the context within which they do their work, and (3) the nature and extent of the support that is provided to them. To understand fully whether, to what extent, and why any variation of the science specialist model is effective, each of these areas needs to be fully explored. The lines of investigation relative to each are described below.

The role of science specialists

There are three primary aspects of the science specialists' work regardless of which model is being deployed: (1) the content and focus of their work; (2) the frequency and duration of their intervention; and (3) the curriculum and materials they work with. In addition there is the experience and training necessary to be successful.

Content and focus. In considering the content and focus of science specialist's work, we need to understand the goals and desired outcomes that guide their work and the tasks and responsibilities they assume in service to those goals. If they are working within a teacher mentoring model, we need to ask what tasks do they perform? These could include lesson demonstrations, lesson observation/debriefing, co- or team-teaching, lesson planning, teaching effective use of materials, teaching science content to classroom teachers, modeling/teaching inquiry instructional strategies, identifying elements of effective lessons, guiding teachers in planning and teaching effective lessons, analyzing student work, and facilitating peer collaboration/mentoring. We also need to ask what other functions specialists perform, and how they carry them out on the ground and under diverse and challenging conditions. What features characterize their interactions with classroom teachers—how frequently and for how long does a specialist work with particular teachers and under what conditions?

At the same time, we need to look at what commitments are required of classroom teachers in the context of specialist-mentor models, what factors influence whether or not they uphold their commitments, and to what degree they are held accountable to fulfill their responsibilities with regard to sustaining the presence of science in their classroom. To what extent are specialists able to adapt their role in response to classroom teachers' needs, capacities, and interests?

If specialists are working within a student instructional model, we need to look at the scope of their instructional responsibilities. Do they teach all students within a school or a subset of students, such as those within a particular grade band? How often do specialists work with students and under what conditions? Do they visit each classroom or have students come to their rooms? To what extent are they able to meet students' particular learning needs, and what structures and supports are provided to specialists in order to ensure that this is possible?

Frequency and duration of the intervention. Regardless of the model, the breadth of specialists' responsibilities varies greatly and must also be understood. For example, are their responsibilities distributed across classrooms within a single school or across schools within a district? Additionally, assuming that specialists must ration the time they have available, to what degree do they prioritize serving teachers (or their students) who are experienced versus inexperienced? inclined to teach science versus less inclined to do so? Just as important, how are those priorities set? Do specialists make these decisions on their own or do they reflect the priorities of their school's or district's instructional leaders?

There is no consensus on the exact responsibilities a specialist should have with respect to teachers and students, or to the school's science program.

Curriculum and materials. Regardless of who is providing science instruction, the curricula and materials used have a significant influence on how the instructional experience unfolds. Therefore, it is important to know what instructional materials science specialists are using, how their materials are selected, what criteria are applied, and what the implications of their use are for specialists or for the classroom teachers they may support. And in addition, what specialists' responsibilities are relative to the acquisition, maintenance, and management of science materials, equipment, and supplies?

Experience and preparation. Finally, it is necessary to understand the experience and preparation that science specialists typically have, and what they need in order to be successful in this role. It is reasonable to expect that there are differences according to the particular model that is in place; so, studies must take these nuances into account. For example, what personal qualities and characteristics, beyond skills and preparation, do science specialists require and how do these vary when the goal is improving classroom teachers' science instruction as compared to improving students' understanding of science concepts? Science specialists arrive at these positions with a variety of prior experiences. Some are simply classroom teachers with an interest in science or teachers needing "coverage." Others have science-specific skills and training. It is worth knowing to what degree classroom experience is called upon in comparison to science content knowledge, and the degree to which this may vary depending on the model. Another important set of questions concerns the continuum of preparation leading to a fully qualified science specialist and, once achieved, the nature of the long-term professional development and support that keeps science specialists engaged and improving their practice. And to what degree do the ongoing professional development supports vary across model types?

Context

Conference participants noted that science specialists do not function in a vacuum, and the context within which they function often dictates the degree to which they are able to realize their intended goals. Policies that identify a vision of effective science instruction and that support specialists' interventions in order to realize that vision have a positive influence on the way science specialists do their work. Also critical in this regard is the degree to which a vision of science instruction is based on common perceptions of students' and teachers' needs, support for the model's implementation from teachers, cost, and school and district accountability. Therefore, an in-depth understanding of the context within which specialists work is critical to understanding whether and how they are able to be effective, however that might be defined.

Rationale for selecting a model. A first step in understanding specialists' work context is to understand why a school or district adopted a science-specialist model at all, and why a particular model was preferred over another. Understanding the specific set of needs, concerns, and conditions that prompted these choices is a crucial component of understanding context. A further question has to do with where the impetus for the specialist model originates? It makes a difference to the success of any model whether it emanated from within a school or district, or from an external funder. Additionally, who makes decisions about what model will be implemented, who contributes to those decisions, and what decision-making process is employed all contribute to the contextual picture and to a specialist's chances of success.

Alignment of expectations. It is most often the case that many different people influence the specialist's work, and therefore it is important to understand the degree to which the vision of the specialist role and the selection process are shared across all stakeholders including classroom teachers, school administrators, and district leaders. When science specialists are working at cross purposes with any of these individuals or groups, their chances for making a positive impact on teaching and learning is reduced. Therefore, research is needed that examines the degree to which specialists' work is aligned to the district's and principal's expectations for science, their expectations for teachers' practice, and their expectations for student learning. Additionally, an understanding of whether and to what extent science specialists have any influence over the attention science receives in their schools and, if so, what strategies they employ to exert that influence will add significantly to our understanding of the role of contextual factors in advancing the work of science specialists.

In a time of competing curricular demands at the elementary level, rising stakes for science, and financial cuts, the field must provide best practices to guide the decision-making efforts of elementary schools to improve their science instruction.

Cost. Calculating the costs of educational programs or interventions is a complex endeavor and one that research has not often taken on. At the same time, when districts or schools are making decisions about how to allocate scarce resources and still maintain the highest level of service to students, understanding the cost of available options is critical. Therefore, studies of the cost of the various science-specialist models would be an invaluable service to the field and to the research literature. Such studies would need to account for such cost categories as personnel; professional development and support; materials, equipment, and supplies; substitutes; space; and transportation.

Accountability. Finally, the degree to which science specialists and their classroom-teacher colleagues are held accountable for carrying out whatever responsibilities the specialist model assigns to them is a critical contextual factor that must be understood. Descriptive studies must examine the formal and informal accountability systems that are in place and the degree to which they are implemented. Therefore, questions that ask to whom specialists report, how they are evaluated, and what criteria are used to determine whether or not they are performing adequately are critical. Just as critical are questions that ask how teachers are evaluated for their science instruction or for their collaboration with their science specialist. In that vein, knowing who conducts such evaluations, how knowledgeable they are about science teaching and learning, and to what extent they can identify/recognize high-quality science instruction is essential.

Value of science learning

Last, and most important, is how the science specialists' context can be characterized with regard to the value placed on science learning. Teaching science in a climate where it has been deemphasized (frequently in order to focus on high-stakes subjects—mathematics and English language arts) is a much different proposition than teaching in a climate where its value has been sustained. When trying to explain the how and why associated with specialists' impact, the importance of this aspect of the instructional context cannot be overestimated. Therefore, a specialist must feel supported if he is to be effective with students.

The supports that influence specialists' ability to do their work and be effective come from four sources: their classroom teacher colleagues, their school administrators, their district, and often institutions of higher education. The questions that research should ask regarding the nature and extent of the support each provides are unique to each source:

Teacher colleagues. It is important to understand the structures that are in place for peer collaboration. For example, are there informal lunch meetings? formal, regular grade-level meetings? inter-visitations? As mentioned above, what are the responsibilities with regard to science teaching that are assigned to classroom teachers, and what characterizes the nature of the interactions between specialists and their classroom teacher colleagues? What is known about a school's culture with regard to its investment in fostering a school-based professional learning community, and what if any, are the structures for including science specialists in that practice?

School administration. We know how important principals' support is with regard to their schools' educational program in general, and it is likewise important to understand the nature and extent of support that principals provide for science in particular. Questions that need to be asked include to what degree principals are knowledgeable about science instruction, to what degree they are provided with training and support regarding leadership for science, and finally, what their personal commitment is to providing their students with high-quality science instruction?

District administration. Because the resources necessary for teaching science emanate from the district, it is important to document the extent to which the resources provided are sufficient. Do science specialists have a ready and adequate supply of the materials, supplies, and equipment they need to implement their instructional programs? What is the nature of the curriculum they are implementing, and to what degree does it represent their districts' planning and investment versus their own? How can the superintendent's support for and commitment to science teaching and learning be characterized and to what extent is he or she able to exercise a positive influence on the presence and strength of a science program?

Institutions of higher education. Institutions of higher education are often important sources of a variety of supports for science programs in general and for science specialists in particular. Thus, it is necessary to understand the role they play, if any, in providing training and certification for science specialists in supporting specialists' instruction via ongoing professional development, faculty involvement in classroom instruction, and/or contributing to program development (e.g. curriculum, student assessment, program evaluation). When such arrangements are in place, it then becomes important to understand the degree to which views on how science should be taught are in alignment.

Cause—
Is There a Systemic Effect?

Understanding the impact of a particular science specialist model and understanding the degree to which these impacts vary across models are, of course, the ultimate goals of this research agenda. With that in mind, the outcome of interest, consistent with the two model types—a teacher mentoring model and a student instructional model—is obviously the impact on the teachers or students they are intended to serve. However, conference attendees also noted that science specialists have an impact on schools and/or districts themselves, and it is important for research to account for those effects if we are to understand the overall consequence of the role of a science specialist.

It is worth noting here that we have separated our discussion of research that would explore the *impact* on teachers, students, and schools from research that would explore the *process or mechanism* by which these impacts would occur. As was mentioned above, we recognize that this separation is a somewhat artificial one, and that it is unlikely and perhaps unwise to examine issues relating to one without considering the other. However, for clarity and ease of discussion, we have approached them separately and trust the reader will recognize the ways in which they are intertwined.

Impact on teachers

The nature of impacts on elementary classroom teachers centers on the ways in which their science instruction has changed as a result of their work with a specialist. Therefore, questions such as, "Are their students receiving *more* science instruction or *better* science instruction as a consequence of the model being implemented?" Of course, quantifying the amount or quality of science instruction is a difficult challenge at best, and one discussed in more detail in the section on Issues and Challenges below.

However, additional teacher outcomes are important as well. These relate to those mediating factors that prevent many classroom teachers from teaching science, such as a sense of inadequacy, or a lack of content knowledge, or an understanding of how teaching science can be integrated with instruction in other subject areas. Increasing teachers' understanding of these issues is not trivial and is often a first step in the process of changing their instruction itself.

Impact on students

The most obvious and important impact on students that conference attendees wanted research to measure and describe was improvement in their understanding of science. Having said that, there is a range of interesting and equally important learning outcomes. For example, has student learning of science concepts improved, has their ability to reason and think scientifically improved, or has their mastery of science skills and command of the scientific process improved as a result of a particular specialist model?

Additionally, just as there are mediating outcomes of interest for teachers, there are also secondary outcomes of interest for students that can be important precursors to improvements in their science achievement. These include their interest in science and their enthusiasm for learning the content; their engagement in the learning process and participation in the work of doing science; and their continued interest in science as evidenced by their involvement in other science-related experiences or their science-course-taking trajectory.

Impact on schools and/or districts

The potential impacts of science specialists on schools or districts were not discussed at length by conference attendees; however, some of the outcomes were raised and deserve mention here because they have systemic implications. For example, science specialists are often ambassadors for science instruction, and their work necessarily requires them to "make the case" convincingly to their colleagues in classrooms or in school or district administrative positions that science should be taught. Therefore, an outcome of interest is the degree to which the understanding of the importance of teaching science has increased as a result of their work. This could be evidenced by, for example, the stabilization of the support structures science specialists require or provide, or the continued provision of the resources necessary for science teaching and learning.

Process or Mechanism— Why or How Is It Happening?

As we have stated previously, the components of the research agenda we are presenting here are inter-related, and it is unlikely that a study would explore any of these questions in isolation. Therefore, the questions below that explore why or how impacts are being achieved (or not) are necessarily related to those questions above in which the nature of the models themselves are defined and described as well as where the impacts might occur. It is expected, then, that we look to the three components of the specialist models (i.e., the specific roles of the specialists, the context within which they work, and the curriculum and materials they work with) to frame investigations that will explain the nature and extent of the impact any of those models have had on teacher or student outcomes.

Asking process questions requires looking within each of those components at their characteristics and complexities as we have outlined them. For example, when considering what it is about the role of the science specialist that might explain their impact on teachers and/or students, we must consider the content and focus of their work, the frequency and duration of their interventions, the curriculum and materials they work with, and their experience and preparation. What can

There is no consistent and commonly accepted language for describing and discussing science-specialist models or their impacts.

we say about each of these aspects of the roles of science specialists, either in comparison to other specialist models or in comparison to other modes of providing elementary science instruction to students, which is a significant predictor of improved outcomes?

Similarly, estimating the importance of context in achieving teacher and student outcomes is a complicated endeavor. Studies must take into account the reason why a particular model was chosen; the alignment of expectations among specialists, teachers, principals, and districts; model costs; and the accountability measures that are applied to ensure the model is implemented as intended. Here, too, we are interested in understanding the relative importance of each of these aspects of context, as well as their significance with respect to one model's impact compared with another's and/or compared with other modes of teaching elementary science.

Finally, to capture the relative importance of the support provided to specialists' to the nature and extent of the impacts they achieve, researchers must account for all of the aspects of support that are described above. These include the nature and extent of teacher collaboration, the role the school and district administration play in supporting their work, and the nature and extent of support provided by institutions of higher education.

Challenges that Research Must Address

The purpose of this research agenda is to make explicit the need for research in general, and the kinds of research questions that must be asked in order to contribute to the advancement of elementary science teaching and learning. Given the complexity of the topic, it is clear that pursuing research on any of the questions raised above will be a complex task characterized by a variety of challenges. We present them here in summary form in order to acquaint researchers, funders, and decision makers with the difficulties of this work, and to provide them with a framework for designing, funding, or applying the knowledge they generate. At the same time, we acknowledge that each of these topics covers a large territory in itself, and any study, if it is to be rigorous and useful, must address them all more thoroughly than we have done here.

Research methods and designs

The research questions raised above are varied in their nature and intent; as a result, the methods and designs that researchers employ to answer them must be varied as well. Raudenbush (2005), in his discussion of research methods and study designs, recognized this and his comments are relevant here, and reiterate much of what we have discussed already.

> … Causal questions—questions about the impact of alternative policies and practices—have emerged as priorities in education research. Questions drive methodological choices, and randomized experiments provide the clearest answers to causal questions arising in social science. … the question before us now is not whether to employ mixed methods in education research generally; rather, the question is how to employ them in the service of a newly dominant research agenda that seeks to evaluate claims about the causal effects of interventions aimed to improve teaching and learning in the nation's classrooms (p. 25).

In addition,

> … experimentation, although necessary, is far from sufficient to achieve the goal of learning about "what works." Research using a variety of methods is essential and should include:
>
> 1. Defining the student outcomes that we seek, so that we can change, build, and validate assessments of those outcomes;
> 2. Supporting novel thinking about how best to intervene, to support preliminary studies of those interventions, and to enable educators to test the feasibility of implementing those interventions in ordinary school settings;
> 3. Clarifying the subsets of children who are in greatest need of intervention or who are most likely to benefit from new ideas about teaching and learning; and
> 4. Studying how resource constraints affect the outcomes of interventions, with the aim of ensuring that new approaches are cost effective.
>
> A final goal is to study why an intervention works, why

> it works for some children and not others, or why it fails. A variety of methodological strategies, including studies of implementation, interviews of teachers and children, and observations of practice, can produce plausible explanations, new hypotheses, and ideas for refining interventions. Descriptions of practice in "settings of origin" (i.e., settings in which a new intervention is initially found effective) can be compared with descriptions of practice when the intervention is implemented on a broader scale (p. 30).

Clarity and definitions of terms

As the conference attendees attested and the existing literature demonstrates, the terms that are used by researchers and their practitioner colleagues are varied and sometimes even confusing. There is no consistent and commonly accepted language for describing and discussing science-specialist models or their impacts. For example, different terms are used to refer to a science specialist such as "resource teacher," "coach," or "teacher leader." Conversely, the term "science specialist" itself may also refer to a wide variety or combination of roles and responsibilities, including, but not limited to, school-level science coaches (Mangiante, 2006), dedicated science resource teachers (Jacobson, 2004), laboratory aides providing technical assistance to classroom teachers (Century and St. John, n.d.), and teachers assigned to teach science because of departmentalization by content at grade level (Gess-Newsome, 1999).

If research is to be usefully applied in the field, the language researchers use needs to be consistent and well understood by decision makers and practitioners.. In fact, Schwartz (2000) specifically cautions that the results of her analysis, though rigorous and empirical, are context dependent and have specific implications for a specific model of specialist in the school system in question.

Measurement

Issues relating to measurement are considerable. Most fundamental is the fact that we have no explicit, observable, and well-accepted definition of effective elementary science instruction, and as a consequence, there are no rigorous and well-accepted instruments designed to measure it. That does not mean that rigorous instruments do not exist; some do, and more are being developed in recognition of this deficit. But in the absence of commonly accepted, observable attributes of high-quality science instruction, they are being created based on operationalized definitions that are unique to each instrument's purpose and the perspective of its designers. While this will enable rigorous studies to be conducted independently, it will not necessarily further our ability to accumulate knowledge across studies, which is our ultimate aim.

Current status of observational instruments relevant to scientific inquiry instruction.

Instrument development is not often the focus of research endeavors; most researchers are interested in the substance that these instruments are designed to assist in measuring. Thus, there are few studies that focus exclusively on instrument development and, as a result, instruments are often tailored to the specific needs of a project with less generalized utility for other projects. The process of developing instruments with evidence of both reliability and validity across projects requires a significant investment. Fields other than education, especially psychology and human development, have seen the utility of this work and, consequently, have produced a number of standardized instruments to measure a range of constructs of key relevance to numerous research and evaluation questions. For example, the Child Behavior Checklist (Achenbach & Edelbrock, 1983), which assesses in a standardized format the behavioral problems and social competencies of children as reported by parents, and the Beck Depression Inventory (Beck, Steer, & Garbin, 1988), which assesses self-reported manifestations of depression are just two commonly used standardized instruments (Plake & Impara, 2001).

Within education, the bulk of the detailed measurement work has focused on the development of standardized tests for student outcomes (Pelligrino, Chudowski, & Glaser, 2001) with less emphasis on capturing delivered classroom instruction, particularly through observation. Yet the importance of understanding the delivered instruction in order to draw conclusions about its impact on student outcomes is clear, which is why most studies of instruction include some observation regardless of the overall evaluation design. Thus, the investment in standardized measures could enable streamlining the instrument development process, resulting in significant savings for individual evaluation efforts while, at the same time, increasing comparability across studies (e.g., cluster evaluations) that are using a rigorously developed and tested instrument.

There currently are several classroom observation measures including (1) the CETP Core Evaluation Classroom Observation (Lawrenz, Huffman, & Appeldorn, 2002); (2) the Reformed Teaching Observation Protocol (RTOP) (Piburn et al., 2000); (3) the NSF-CETP Student Teacher Videotaped Lessons Scoring Protocol (Online Evaluation Resource Library, 2004); (4) the Science Teacher Inquiry Rubric (STIR) (Beerer & Bodzin, 2004); and (5) the 2003-04 Local Systemic Change Classroom Observation Protocol (Horizon Research, Inc., 2003). Following are brief descriptions of these instruments and how the Inquiry Science Instruction Observation Protocol (ISIOP) differs from them. The CETP Core Evaluation Classroom Observation focuses on type of instruction, student engagement, and cognitive activity of students using a time-sampled observational method. It also includes ratings of "key indicators" that represent a range of outcomes and expectations for students. The items were designed to be global and capture all the possible aspects of teaching rather than focusing on a refined documentation of elements of scientific inquiry instruction. The Reformed Teaching Observation Protocol (RTOP) was designed to assess both mathematics and science instruction in grades K-20 and is heavily grounded in the national mathematics and science standards. This instrument uses an event sampling method and has a number of items that relate to some aspects of our conceptual framework of inquiry instruction. However, as with the CETP, the items were written to capture reform practices, not the grade and discipline-specific manifestations of scientific inquiry instructional practices. The Science Teacher Inquiry Rubric (STIR) was developed to assist elementary teachers in their own self-assessment of the essential features of inquiry. This protocol uses a continuum of learner-centeredness to teacher-centeredness at a very general level of descriptive precision. The 2003-04 Local Systemic Change Classroom Observation Protocol was designed to record and rate mathematics and science lessons from classrooms in Local Systemic Change districts. This comprehensive protocol is designed as an evaluation instrument to capture all of the aspects of classroom instruction. While it does reflect some aspects of scientific inquiry instruction, it does so in the larger classroom context. Although some detailed information about the development and psychometric properties of the instruments above accompanies the instruments, for most, the development process and evidence of psychometric properties are not readily available to aid evaluators in determining the utility of these measures for their specific uses and, thus, the validity of the interpretations made from these instruments.

Research must be made accessible and useful for practitioners and decision makers, rather than targeting only academic audiences.

In addition to the existing instruments described above, more are being developed. One example is the *Inquiry Science Instruction Observational Protocol (ISIOP)*. By actively collaborating with a number of the instruments' developers, the ISIOP (D. Minner, personal communication, July 31, 2008) has built on the strengths of these existing instruments, and has incorporated the numerous suggestions from these advisors into the protocol. The ISIOP is designed to assist evaluators and researchers in determining the nature of and extent of scientific inquiry instruction and best practices that are present in middle grades science classroom teaching.

Another example, described in more detail in the article by Jeanne Rose Century, included in this journal, is the Fidelity of Implementation, FOI. FOI **is** a suite of instruments for measuring the use of several reform based K-8 science programs. A User's Guide that accompanies the instruments will describe their established reliability and validity and explain how to adapt the instruments for use with other programs or for classroom instruction where no particular program is used. The suite will also include observation and interview protocols, questionnaires, and a log.

In addition to measuring science instruction, the issue of measurement continues to be relevant for student and teacher outcomes. For example, we are interested not only in students' understanding of science concepts, but also in their understanding of the scientific process, and in their ability to think and reason scientifically. There is a dearth of rigorous instruments that are designed to capture change in these skills, particularly at the elementary level. Likewise, teachers' sense of efficacy with regard to science, their pedagogical knowledge regarding the science content they are teaching, or their comfort with and ability to use curriculum materials and equipment all require instruments that, as yet, do not exist or, if they do, are not based on commonly accepted frameworks that enable comparison across studies.

Complexity and variation of contextual factors

As the discussion of the context and its components demonstrated, the environments within which these models must be studied are fluid and multifaceted. They can change quickly, and one change, such as a loss of funding or a change in leadership, often causes ripple effects in a variety of other areas. For example, conference attendees noted that specialist models often had to change their design with the arrival of a new principal or district leader, a change in available resources, or a shift in district priorities.

Understanding the relationship between contextual factors and specialist models is critical to understanding the nature and the extent to which a particular model has had an impact. Likewise, looking across models and the contexts within which they operate will shed light on how each influences the other. Conference attendees raised the concern, however, that although it is critically important to understand these relationships, the fact that they are so unique to each place and time makes it particularly challenging to study in one location, to identify patterns across studies, and to generalize findings. We do not highlight these constraints and challenges to suggest that examinations of context are too difficult to do well but, rather, to suggest to researchers, funders, and practitioners that they should be taken into account when planning, supporting, or utilizing research. These challenges suggest, as Raudenbush (2005) explained, that the value of multi-site and longitudinal studies and the use of in-depth interviews all require considerable time and resources.

Challenges associated with working in schools and districts

For all the reasons stated above, working in schools and districts is a difficult proposition. They are busy places in which the players face many pressures and constraints, and so the importance of being present without being an imposition cannot be overstated. At the same time that we have highlighted the value of conducting long-term studies that include, for example, in-depth interviews, we also recognize the difficulties of conducting such studies because access to the important players can be extremely limited. Similarly, as we seek to understand how the outcomes of different models vary across population groups, the issue of whether or not schools and districts have the necessary data, in a format research can use, and whether it will be made available becomes critically important. If studies are to be useful, they must have access to the data they need, whether it comes from district records or individuals.

Reaching the right audiences

Research must be made accessible and useful for practitioners and decision makers, rather than targeting only academic audiences. This work has meaning for the research field, of course, but it is critical for the field and should be made available to them. The window of opportunity to influence policy makers is often much shorter than the time it takes for research to work its way through the peer review process and be published in academic journals. That's a systemic problem of the academic world that affects the value and utility of research to the field.

Summary

The January/February 2008 issue of *Educational Researcher* focused on evidenced-based research, and the series of articles examined the challenges and concerns we have raised above in great detail. In his article in that series, Finbarr Sloane recalls Benjamin Bloom's plea for rigorous education research, which continues to be relevant today as it explains our reason for holding the conference on elementary science specialists and on creating this research agenda as a result of it. Bloom (1972) wrote:

> In education, we continue to be seduced by the equivalent of snake-oil remedies, fake cancer cures, perpetual-motion contraptions, and old wives' tales. Myth and reality are not clearly differentiated, and we frequently prefer the former to the latter … . We have been innocents in education because we have not put our own house in order. We need to be much clearer about what we do and do not know so that we don't continually confuse the two. If I could have one wish for education, it would be the systematic ordering of our basic knowledge in such a way that what is known and true can be acted on, while what is superstition, fad, and myth can be recognized as such and used when there is nothing else to support us in our frustration and despair (p. 332).

Elementary school principals and district leaders are facing the problem of providing science instruction to children when they are uncertain about how best to do so within the limitations they face. On one hand, this is a happy dilemma for those of us who have long felt the absence of science from elementary classrooms. Nevertheless, making important decisions in the absence of useful information is undesirable at best, most likely wasteful, and harmful at worst. Regardless of their uncertainties, decision makers must deploy the resources at hand and make an effort to meet the demands before them.

This research agenda attempts to create and organize knowledge about the relative impact of one approach to meeting the demand for elementary science instruction. It lays out the questions that should be raised, and provides a framework for asking those questions and interpreting the cumulative findings. It will not be cheap; however, good research has never been so. In the past, education research has been woefully under-funded, which explains, in part, why it has been considered under par. Our purpose is to begin the process of investigating these questions by organizing the work and laying out the challenges that should be considered in the process of taking it on. Our hope is that our research and practitioner colleagues can begin this work together so that the science instruction our children receive will excite, stimulate, and inform their thinking as young people and as they mature into productive citizens.

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