

Hiring a Science Specialist to Improve Elementary Science Instruction Is Just the Beginning:
Supporting Schools to Maximize the Impact of Science Specialists

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Abstract

This study examined the effect of professional development on elementary teachers' self-efficacy for science teaching, the quality of science instruction in participating teachers' classrooms, elementary teachers' content knowledge, the co-planning and co-teaching practices of science specialists and regular classroom teachers, and elementary student outcomes. Using a quasi-experimental design with matched comparison group measures, 28 elementary teachers in an urban school district were assigned to a treatment or control group. Treatment teachers were provided support for two summers and one academic year. Support included science methods instruction in the summers conducted collaboratively by science education and science content faculty, in-class coaching support by a science education faculty member, and instruction during the academic year outside regular school hours by a science education faculty member emphasizing continued science methods instruction and action research strategies to improve science instruction. Data were collected through surveys, content tests, interviews, observations, and state science achievement tests. Data highlight the positive impact of the project on teachers' confidence for teaching science, the content knowledge of both teachers and students, and the quantity and quality of science instruction in the classroom while highlighting the importance of providing specific support to schools so that science specialists can be utilized effectively.

Hiring a Science Specialist to Improve Elementary Science Instruction Is Just the Beginning: Supporting Schools to Maximize the Impact of Science Specialists

Subject/Problem

There is an increasing shortage of high school and college students enrolling in advanced coursework in the STEM areas. The result is a growing deficit in the pool of qualified applicants for STEM area careers (CCAWMSETD, 2000). Compounding this problem is the current quality of students' science classroom experiences. Research shows that science and mathematics teaching in the United States is failing to produce future generations with strong analytic skills (Martin, et. al, 1997, 2004; Mullis, et. al, 1997, 1998, 2004; NCMSTTC, 2000), indicating a need for stronger science teaching in the pre-collegiate years beginning with the pre-kindergarten through sixth grades (NSRC, 1997; NRC, 2007).

Standards for science highlight the necessity for science instruction grounded in children's real world experiences and aligned with community needs and interests so science learning is consistent with the nature of science (AAAS, 1993; NRC, 1996; NRC, 2007) and addresses multicultural perspectives (Banks, 2001; NRC 2007) and social justice issues (Barton, et. al., 2003; Darling-Hammond, French, & Garcia-Lopez, 2002; NRC, 2007). Additionally, recent reports emphasize the need to create curricula that integrate creativity and analytical thinking if the United States is to remain competitive in the global economy (NCEE, 2007; NRC, 2007). Elementary teachers must be able to design creative science experiences that incorporate analytical thinking and are tailored to fit their particular students' needs, interests, and abilities. Effectiveness studies indicate that instruction grounded in a real-world application, such as the environment, results in positive student outcomes (Athman & Monroe, 2003; Bartosh, 2003;

Coyle, 2005). In the true spirit of science, elementary teachers must be adept at providing science instruction that at times may be unpredictable, and requires creativity. Various studies highlight the importance of teacher training and its impact on children's achievement (Darling-Hammond, 2000, 2003; Ferguson, 1991; Wenglinsky, 2000) and the necessity for training to include preparation in both content and pedagogy (USDOE, 1999).

It has been suggested that science specialists at the elementary level may be employed to improve the quality of children's science learning experiences (Abell, 1990; Jones & Edmunds, 2006; Rhoton, Field, & Prather, 1992; Schwartz, Abd-El-Khalick, & Lederman, 2000). This paper contributes to the literature on data-driven suggestions for how to effectively utilize elementary science specialists by providing information about the impact of professional development targeting regular classroom teachers' utilization and integration of science specialists into their science teaching efforts. More specifically, this study examined the effect of professional development offered in partnership between a school district and university on elementary teachers' self-efficacy for science teaching, the quality of science instruction in participating teachers' classrooms, elementary teachers' content knowledge, the practices of science specialists and regular classroom teachers with respect to co-planning and co-teaching behaviors, and elementary student outcomes.

Design/Procedure

As part of a larger city-wide emphasis on science, two urban elementary schools were selected for intensive study and support from a local university. One school was selected because of its poor student scores on state standardized science tests, while the other school was selected because of its students' similar demographics and socio-economic status, while managing to perform somewhat better on the state's standardized science tests. Both schools needed to

improve, and the future was uncertain for at least one of these two schools. Teachers participated in sustained, intensive professional development for science content knowledge and teaching skills based on the state's standards in science and the students' lowest scoring science areas on the fifth grade science standardized test administered by the state. Special attention was given to how to best assist the participating schools in using their science specialists more effectively and in a more integrated fashion where co-planning and co-teaching were established as part of the school norm. To facilitate using science specialists for embedded professional development of teachers who teach science, the program focused on the following:

1. Science instruction to increase science content knowledge;
2. Observing, analyzing, and piloting active learning strategies which actively engage students in their own learning;
3. Mentoring from science education faculty and the science specialist to increase awareness of effective science teaching; and
4. Conducting collaborative action research in their own classroom to see what helps their students improve academically.

For two summers, teachers (N=28) participated in two-week workshops conducted collaboratively by university science education faculty, university science content faculty, and the schools' employed science specialists. During the academic year, teachers attended planning meetings with the science specialist and weekly 45-minute science sessions co-teaching science for their students with the science specialist. Teachers also attended sessions offered outside regular school hours to work in grade level teams to conduct collaborative action research on their students' learning. There were a total of 156 contact hours per teacher (48 hours per summer for two summers and 40 sessions during the academic year for a total of 60 hours).

Throughout the program, university science teacher educators and university scientists mentored the teachers, including the schools' science specialists.

Designed in collaboration with the school district's science curriculum specialist, participating school principals, and science and science teacher education faculty from the partnering university, the goals of the project were to:

1. raise student achievement in science as well as their interests and attitudes toward science.
2. increase teachers' understanding of science content knowledge and skills
3. increase teachers' confidence for, and practices in, collaboratively planning and teaching hands-on, inquiry-based science that actively engages students
4. increase teachers' understanding of assessing science learning and using data to drive instruction
5. build a network of support and learning community that will provide ongoing support throughout the school year for teachers of science in elementary schools

To achieve these goals, the design of the inservice teacher development model utilized a literature base identified in collaboration with the participating school district and science teacher educators involved in the project. Literature spanned the areas of standards-based learning, creativity in teaching, teaching for understanding, use of technology to support teacher creativity, situated learning theory involving a diverse community of support, social cognitive theory to support self-motivation and self-regulation, research on effective professional development, and awareness of diverse perspectives and the culture of science (see Table 1).

The evaluation plan utilized a quasi-experimental design with matched comparison group measures. Impact on teachers' science content gains were based on pre- and post-tests for two

science content tests. To better assess impact, one science content test administered to treatment teachers was additionally administered to a set of matched control teachers. Measures of student impact included a quantitative analysis comparing students' prior standardized test scores in science for third and fifth grade students. In addition to state standardized science test scores, teacher-made science tests were developed to measure students' content knowledge gains, as well as on-site observations utilizing a standardized instrument. These teacher-made tests were administered to students of treatment teachers and their matched control counterparts. Similarly, impact on teachers' self-efficacy for teaching science was measured via a likert-scale instrument (Riggs & Enochs, 1990) that was administered as a pre-post assessment to both treatment and matched control teachers. Impact on teacher practices were observed by completion of an observation sheet based on Constructivist Learning Environment Survey (; Taylor, Fraser, & Fisher, 1997). To gain further insight, open-ended questions for teachers and a case study protocol for science specialists were developed by a team of science teacher educators and the program evaluator to ensure reliability and validity of response.

Quantitative data were analyzed using SPSS and Microsoft Excel. Qualitative data were analyzed using Microsoft Excel to assist with the constant comparative process of grounded theory (Glaser, 1978; Glaser & Strauss, 1967; Strauss & Corbin, 1998) and cross-case synthesis (Yin, 2003). As responses were examined, they were coded, tallied, ranked, and analyzed for emergent themes (Creswell, 2008).

Findings and Analysis

A summary of selected significant quantitative findings and relevant qualitative findings are reported in this paper.

Improved Science Content Knowledge Among Teachers and Students

As evidenced by content test score results, teachers made significant gains in their science content knowledge in the science areas of focus during training. As compared to their matched control counterparts the difference in the content knowledge of teachers who participated in training was significantly greater than those who did not participate in training ($M_T = 86\%$, $M_C = 69\%$, $t(16) = 2.22$, $p = .04$). Additionally, students of treatment teachers experienced significantly higher gains on teacher-developed science content tests as compared to the students of matched control teachers ($M_T = 15.7\%$, $M_C = 9.1\%$, $t(185) = , p = .03$).

Increased Teachers' Confidence for Teaching Science

Quantitative findings revealed that participation in the training corresponded with improvements in teachers' confidence levels for teaching science ($M_T = 3.23$, $M_C = 3.93$, $t(19) = 3.96$, $p = .001$). Qualitative findings reveal that teachers who participated in the summer workshops and after school follow-up sessions felt more capable of teaching science, felt more knowledgeable in how to teach science via inquiry, and felt that they were more capable of impacting the science content knowledge of their students. Additionally, qualitative findings from observation of classroom instruction, a review of classroom artifacts, and teachers' self-report indicated that action research projects were an extended opportunity for teachers to apply their knowledge of science content and pedagogy to further advance their confidence for implementing effective science teaching.

Formation of a Community of Learners Dedicated to Science Education

The teachers increased their participation in two summer workshops and throughout the academic year, and qualitative findings revealed a community of support developing among the teachers and science specialists for science teaching. With the encouragement of university

faculty's weekly on-site presence and faculty's modeling of how to co-teach with a science specialist, regular classroom teachers began co-planning and co-teaching with their lead science laboratory teacher on a more regular basis. However, regular classroom teachers' attention to these activities was dependent on the extent to which they viewed the science specialist as a leader in their school.

As a result of the program, new science fieldtrips were planned and conducted. In addition, teachers ordered and received new supplies and materials that they otherwise would not have had. With the guidance of university faculty, action research projects were conducted during the academic year by teachers on their students' performance in science. Workshops and Saturday sessions also gave participating teachers an opportunity to share and reflect on their science teaching practices and learn from each other.

Qualitative findings indicated that there was a need across teachers in the project for more structure and support for how the science specialist and elementary generalists would share responsibility for students' learning. This need was communicated by both the science laboratory teachers as well as the elementary generalists. Consequently, an organizational framework for curriculum and lesson planning was developed by the participating teachers with support and guidance from university faculty with expertise in elementary science teacher education and research (see Table 2). Qualitative results highlighted teachers' reliance on this framework to define their roles in the science planning and teaching process.

Contribution to Teaching and Learning Science

This study provided evidence of positive impact of professional development efforts on teachers' and students' content knowledge, teachers' science teaching efficacy, and quality of science instruction with respect to co-planning and co-teaching behaviors. Additionally, the

study's findings resulted in a series of data-driven suggestions for how school leaders can support the effective use and integration of science specialists to improve the quality and impact of elementary science instruction. These suggestions included:

1. Prepare teachers, staff, and parents for the new program.
2. Establish the role of science laboratory teacher as a leader in the school who will co-plan and co-teach with elementary generalists.
3. Utilize experienced and academically-prepared teachers as the science laboratory teacher.
4. Consider the addition of a paraprofessional as a science laboratory co-teacher.
5. Form an alliance with a local university.
6. Assign a mentor early that fits the specialized needs of science laboratory teachers.
7. Designate adequate space for the science lab room.
8. Provide an adequate budget for supplies and plan for reimbursement of consumables used during instruction.
9. Provide access to curriculum and lesson plans as well as time for curriculum development.
10. Provide latitude to modify and create new programs based on action research findings.

Relevance to Science Education Research Community

Within the science education research community, members at the intersection of science teacher educators and research struggle to develop, implement, and assess effectiveness of programs designed to support quality science instruction at the elementary level. This study illustrated that quality science instruction does not merely happen once a science specialist has been hired. Teaching science can be a daunting task for elementary teachers, especially those with weak science background experiences. However, the presence of a science specialist in the

school does not mean that regular classroom teachers no longer have to teach science. Instead, a community of support is needed to ensure that the resources of a science specialist are effectively utilized. As school districts and school leaders consider the employment of science specialists, clearly there is a need for a more thorough understanding of how effective support programs targeting this special population of teachers function so that their potential can be realized. Using a quasi-experimental matched treatment-control group design, this study examined the mechanism of effectively supporting elementary schools to improve the quality of science instruction in their schools. With more schools turning to science specialists as the answer and continuing emphasis on university-school partnerships to provide professional development support, it is imperative that the science education research community consider what is needed to create professional development programs that support positive, productive interactions at the elementary level among regular classroom teachers, science specialists, and university faculty.

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Table 1

Literature base for the inservice teacher professional development model

Theme	Resources used
Standards-based learning	AAAS, 1993; NCTM, 2000; NRC, 1996
Creativity in teaching	Bereiter & Scardamalia, 2003, 2006; Feldman, Csikszentmihalyi, & Gardner, 1994; Guilford, 1950; Kaufman & Baer, 2006; Lubart, 1994; Simonton, 2006; Sternberg, 1999; Sternberg & Lubart, 1991, 1995; Torrance, 1962
Teaching for understanding	Hiebert, et. al., 1997; Sterling, 2001, 2008; Wiggins & McTighe, 1998; 2007
Use of technology to support teacher creativity	Andersson, 2006; Frazier & Sterling, 2008; Morgan, 1993
Situated learning theory involving a collaborative, productive community of participants with a wide range of expertise	Lave, 1988; Lave & Wenger, 1990; Sterling & Frazier, 2006
Social cognitive theory to develop self-motivated and self-regulated teachers	Bandura, 1997; Zimmerman, 2001
Best practices research on effective teaching and professional development programs, which indicates the importance of a collective sense of commitment and responsibility for serving children	Guskey, 1995; Sterling, 1997, 2000; USDOE, 1999
Awareness of diverse perspectives and the culture of science	Barton, 2000; Brown, 2004; Lemke, 2001; Vygotsky, 1962

Table 2

Model for an Effective Elementary Science Program

Instructional Phase and Purpose (5-E Model, BSCS, 2006)	Planning	Implementation	Location
Engage – Introduce and spark children’s interest in topic through asking a question, presenting a problem, or sharing a discrepant event	Regular classroom teacher and science laboratory teacher	Regular classroom teacher	Regular classroom
Explore – Use hands-on materials to concretely observe and experience key aspects of topic	Regular classroom teacher and science laboratory teacher	Regular classroom teacher	Regular classroom
Explain – Generate and provide explanations of science concepts based on experiences in previous phases through input from teacher, fellow students, textbook, and/or technology	Science laboratory teacher(s)	Science laboratory teacher(s)	Laboratory
Elaborate – Apply and refine new knowledge to new situations via continuing observations, design of experiments, and interactions with fellow students	Science laboratory teacher(s) with classroom teacher	Science laboratory teacher(s) with classroom teacher	Begin in laboratory, finish in classroom
Evaluate – Illustrate new understandings and skills through teacher and student-directed performance	Classroom teacher with input from science laboratory teacher(s)	Classroom teacher	Regular classroom