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Using Scientists and Real-World Scenarios in Professional Development for Middle School Science Teachers

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Middle school science teachers were involved in a problem-solving experience presented and guided by research scientists. Data on the teachers' perspectives about this professional development and any impact it may have had on their teaching practices were collected through interviews, surveys, and classroom observations. The findings show that the professional development experience was positive, although one concern expressed by teachers was their lack of understanding of the scientists' vocabulary. Using scientists and real-world scenarios was shown to be an effective strategy for encouraging middle school teachers to teach science as a process and help them strengthen their science content understanding.

Introduction

To provide professional development for middle school science teachers prior to their use of inquiry-based curricular materials, real-world, scenario-based problem-solving sessions led by scientists were presented in the areas of physical, life, and earth science. The National Science Education Standards (NSES; National Research Council [NRC], 1996a) have specifically stressed that professional development programs for science teachers need to help teachers learn science subject matter and develop inquiry abilities through their own experiences with conducting inquiry science (NRC, 2000). Loucks-Horsley, Hewson, Love, and Stiles (1998) suggested that a successful professional development strategy for science teachers may be facilitating the formation of partnerships between classroom teachers and practicing scientists. The key elements of the partnerships, according to the authors, are strong collaboration between the partners; scientists taking on the role of content experts; and consistent values, goals, and objectives between all partners. Loucks-Horsley et al. described clearly the benefits the teachers may gain from this type of professional development:

> *For teachers, working closely with scientists and mathematicians provides exposure to role models and brings real-world application of subject*

> *matter into perspective. They have the opportunity to learn more about how the scientific and mathematical processes work—what scientists and mathematicians do and how and why they do it. Teachers are exposed to new perspectives and a different professional culture, and the partnership keeps them in touch with a broader knowledge base. (p. 135)*

Involving teachers in inquiry investigations with scientists as mentors is in line with Supovitz and Turner's (2000) description of the critical components of high-quality professional development. The authors suggested, "First, high-quality professional development must immerse participants in inquiry, questioning and experimentation, and therefore model inquiry forms of teaching" (p. 964). Supovitz and Turner stated that professional development must also provide teachers with concrete teaching tasks and revolve around the teachers' own experiences with students. Also, high-quality professional development should "focus on subject-matter knowledge and deepen teachers' content skills" (p. 964). Professional development experiences involving scientists and science teachers hold the promise of encouraging a teaching and learning model in schools that parallels the way in which scientists and engineers uncover knowledge and solve problems.

Professional development programs where scientists are asked to teach teachers require the scientists to examine their own teaching and reflect on their modeling of active learning and quality process and content teaching (Loucks-Horsley et al., 1998). One of the six guiding principles defined by the Committee on Science and Mathematics Teacher Preparation (2001) specified that scientists, mathematicians, and engineers need to become more involved in and better informed about providing content knowledge to teachers. This type of professional development may allow scientists to have a voice in their local science education reform efforts and be more effective in their own outreach efforts to schools, which are often part of university or corporate strategies for community involvement.

Professional development programs involving scientist-teacher partnerships may generate certain problematic issues. Prior to professional development experiences, scientists and teachers may need to receive orientation regarding each other's worlds so that the scientists understand student competencies and developmental learning and the teachers start to understand something of the nature of science (Eisenhower National Clearinghouse [ENC], n.d.). The teachers' lack of comprehension about what science is and how it is conducted by scientists may hinder collaboration between scientists and teachers. Discussions with teachers have shown that scientists are often perceived as threatening, intimidating, and not interested in working collaboratively with teachers (Moreno, 1999; NRC, 1996b). Another issue may be that scientists are viewed as the expert who is being called in to tell the teachers what to do: "Teachers sometimes fear intrusion by outsiders, especially those viewed as the ultimate experts" (ENC, p. 29). Through discussions with teachers, scientists can begin to appreciate the complexities of teaching science, such as adapting curricula, conducting assessment, or organizing materials. To build a successful collaboration between scientists and teachers "requires that each value the knowledge and expertise of the other, recognize the importance of the roles played by each person, and begin to learn about each other's work" (Loucks-Horsley et al., 1998, pp. 135–136).

In this project, we introduced a reform-based curriculum and the science content of the curriculum to teachers through involvement in a problem-solving experience presented and guided by research scientists. This was an effort to help teachers progress toward a deeper understanding of the content, the curriculum, and how students may learn science through inquiry. Introducing teachers to new science content through their involvement in a problem-solving experience with scientists is supported by Supovitz and Turner's (2000) conclusion that content preparation was the most powerful individual teacher factor in their models of successful professional development of science teachers. Also, as stated by Cronin-Jones (1991), "If teachers understand why a curriculum addresses certain objectives or recommends particular instructional strategies, they will be more willing to try to use the curriculum as intended" (p. 249). By involving teachers in an inquiry investigation, we hoped to provide them with an understanding of teaching and learning through inquiry that they could adapt and utilize in their own classrooms. Teachers' beliefs about students' learning and why certain instructional strategies are effective appear to have a great impact on how teachers will implement a curriculum in their own classroom (Tobin, Tippins, & Gallard, 1994). It has been established that teachers make instructional decisions based on complex interactions between beliefs and knowledge (Bryan & Abell, 1999; Magnusson, Krajcik, & Borko, 1999). In addition, research (Crawford, 2000; Keys & Bryan, 2001; Keys & Kennedy, 1999) has emphasized that teachers' ideas and practice about inquiry are varied and complex; therefore, by providing a central, common, inquiry-learning experience, we hoped to strengthen the teachers' implementation of inquiry in the classroom.

Description of Professional Development Project

A statewide program to assist school districts with science education reform, Washington State Leadership and Assistance for Science Education Reform [LASER], provided funding and support for four local school districts to initiate and implement an effort focused on improving middle school science in southeastern Washington. The LASER program provided support for science education reform by focusing on the following critical elements: (a) high-quality curriculum, (b) sustained professional development, (c) materials support, (d) administrative and community support, and (e) student and program assessment. The four participating school districts were working to initiate the use of standards-based materials by middle school teachers, strengthen leadership at the district level, and develop a set of common goals for the improvement of middle school science.

The process to improve middle school science in the four school districts involved introducing high-quality, inquiry-based curriculum materials and providing *initial-use* professional development for the teachers who would be asked to teach these materials. In the first year of the project, following a phase of classroom piloting, the school districts selected three modules (kits) for adoption, one each for earth, life, and physical sciences. These modules were developed with National Science Foundation funding and were all standards based and inquiry oriented. They were the Science and Technology for Children for Middle School (STC/MS) module; Catastrophic Events module, developed by the National Science Resources Center (a nonprofit organization formed from a partnership between the Smithsonian Institute and the National Academies); and two Full Option Science System (FOSS) modules, Diversity of Life and Electronics, developed at the Lawrence Hall of Science, University of California, Berkeley.

All the middle school science teachers designated to teach the new modules in the fall semester of the school year were asked to attend either an initial-use 4-day training in the summer or a 2-day training in the early fall. About 50% of the four districts' middle school science teachers attended the 4 days of professional development during the summer, approximately 3 weeks prior to the start of school. The remaining 50% attended the 2-day training in September. This paper focuses on the 4-day professional development offered to the teachers during the summer. The intent of this 4-day professional development was to combine a 2-day inquiry-based investigative experience focused on the nature of science and technology with 2 days of introduction to the actual science module. This initial-use session involved the teachers in 2 days spent with a practicing research scientist where they were immersed in a simulated science and technology scenario. Each of the three scenarios (one each for earth, life, and physical science) was designed by the scientist presenting the professional development with input from a teacher (designated a lead teacher) who had already used the module in his or her classroom. These scenarios were designed to help teachers build a deeper understanding of how science and technology are conducted outside the classroom. Another major objective of involving teachers in these scenarios was to strengthen teachers' understanding of inquiry science and, consequently, their implementation of inquiry-based kits. The first 2 days of the 4-day training, the *scenario session*, was followed immediately by 2 days of kit training spent with a classroom consultant experienced with teaching the module, designing the module, or both.

Kit Training. During the kit training, teachers learned about the sequence of lessons, materials issues, recommended assessment strategies (for example, science notebooks), and any classroom management involved with teaching the materials. These 2 days were spent reviewing the module activity by activity to familiarize teachers with the activities and assignments. Generally, the leader of this kit training led the teachers through the curriculum, providing suggestions for using the kits in the classroom and examples of student work for each activity. These kit trainers were not involved in the first 2 days of the professional development, and no effort was made to tie their trainings to the investigations during the first 2 days.

Scenario Session. The 2-day scenario session was a problem-based, adult learning opportunity (planned for teachers rather than students) that modeled the way scientists and engineers answer questions about the natural world and solve problems that meet a human need or want. Participating scientists designed three scenarios (one each for life, earth, and physical sciences), with input from four local teacher leaders who had previously piloted a specific life, earth, or physical science module in their classrooms. During a 1-day planning session, the scientists responsible for each scenario met with the teacher leader experienced with that module and designed the scenario; the scientist and this lead teacher later facilitated the 2-day scenario sessions. This scenario was based on a real-world problem and designed to challenge the teachers as they experienced an inquiry investigation. The content of the scenarios was aligned with, but not a duplicate of, the basic science concepts and skills found in the modules being used. These scenarios were based on the general description of an inquiry science investigation from the NSES for grades 5–8: (a) identify questions; (b) design and conduct investigations; (c) collect, analyze, and interpret data; (d) develop explanations, predictions, and models based on the evidence; (e) recognize alternative explanations; and (f) communicate procedures and explanations (NRC, 1996a). The objective of the scenario investigations was to involve teachers in an inquiry experience that was built on science content knowledge relevant to the specific kit the teacher would be teaching; the scenarios were not designed to support teachers' implementation of the kits. Through the use of the problem-solving scenario, teachers were engaged in activities designed to help them explore or discover explanations and create solutions. Teachers were given an opportunity to be actively involved in making sense of and testing their explanations and solutions and then applying these to make sense of the question or problem posed by the scenario. In the process, it was hoped that the teachers would begin to discover the interplay of inquiry and problem solving, as well as the fact that investigation and problem-solving activities continually generate new questions and problems.

The general format of the scenario sessions was that the scientists presented content information and set the context of the problem to be solved. The challenge was presented, and the teachers then worked together in groups. The scientists acted as mentors and facilitators to the groups of teachers as they worked on solving the problem. The scientists supported the teachers by providing models, resources to access, and strategies for the teachers to use as they conducted their inquiry investigations. The teachers reported back to the scientists and the group as a whole for a final endorsement on their solutions. A brief description of each of the three science and technology scenarios (earth, life, and physical sciences) follows.

Earth Science. Teachers investigated a variety of meteorological and geological factors that would affect the geographic placement of a large amusement park. They were also asked to take into consideration the economic concerns facing a community where a new amusement park might be placed.

Life Science. In the life-science scenario, the teachers were challenged to make a bigger French fry without using any more potato. Through the use of genetics, the teachers were asked to find a way to plump potatoes up so they would have more volume, but overhead would not go up. Second, they found a genetic marker in a strand of DNA.

Physical Science. After watching a clip from the movie, "Apollo 13" (Grazer, Howard, & Lovell, 1995), the teachers were given a bag of parts and pieces of common household materials and challenged to build a simple circuit. They researched how circuits, capacitors, and resistors work. After building and testing their circuits, they set up the circuit so the light bulb involved would flash at a specific rate; then a simulated "gate" was set up that would only open when the light flashed at specific rates. The circuit's components were manipulated to get the flash rates right to open the gate.

Research Questions

The specific focus of this paper is the professional development provided by the scientists as the teachers were involved in the real-world, problem-solving scenarios. To evaluate the success of using real-world scenario problems, combined with instruction by scientists in this professional development, reform-based project, the following questions were explored:

1. What are middle school science teachers' perspectives on a professional development experience involving scientists and scenarios to provide science content and process instruction?
2. What aspects of this type of professional development are incorporated into these teachers' science teaching?

Methods

Participants

The participants in this study were 47 middle school science teachers, all having different backgrounds and training in science. These teachers were teaching in middle schools in four school districts in an urban area of southeastern Washington. As the professional development occurred during the summer vacation, the teachers were paid a daily stipend, and inservice professional development credits were available. These 47 teachers volunteered to participate in the 4-day training. Other middle school science teachers in the four school districts chose either to take a 2-day training in the fall (40 teachers) or not to implement the specific science kit until later and, therefore, did not attend a training session (13 teachers). The teachers involved in this study had not previously been involved in teaching inquiry science. A small number (approximately 10) of the 47 teachers had attended general presentations on inquiry-based curricula but had not used the curricula in their own classrooms. Also participating in the project were four research scientists, three from a national research laboratory and one from a private 4-year college located in one of the school districts. The four scientists involved with this professional development were an electrical engineer, a hydrologist, a meteorologist, and an evolutionary biologist.

Data Collection

To explore the teachers' reactions to 2 days of science instruction by the research scientists and how this experience affected their classroom practices, data were collected through surveys and interviews. Classroom observations were conducted to gain a picture of how the teachers implemented the information and strategies learned during the professional development experience. Comments about and reflections on the scenario sessions were collected from all participants, teachers, and scientists throughout the project in a researcher's (Morrison's) observation log.

Surveys. The teachers were given a presurvey at the start of the 4-day session on which they were asked to provide a rating ($1 = $ low, $4 = $ high) of their (a) understanding of the underlying concepts of the specific unit, (b) ability to teach the content using the teacher's guide, and (c) confidence in how prepared they were to teach the kit. The surveys were administered again at the end of the 4-day professional development; the teachers provided their rating of the same three aspects as on the presurvey. In addition, on the postsurvey, the teachers were asked to provide their comments on the aspects they liked the best and the least about the workshop and to provide suggestions for future professional development opportunities in science. The pre- and postsurveys were modeled on surveys used in previous professional development workshops where teachers were trained to use science kits, but no formal validity was established.

After teaching the kits at least one time, all teachers were asked on a post-postsurvey through an email message to respond to the following questions: "How did the 2 days working with and getting to know the scientist affect your teaching of the kit material?" and "How did your involvement in the real-world, inquiry-based investigation affect your teaching of the science concepts or implementation of the kit on that topic?"

Interviews. Prior to the summer workshop, a focus group of seven teachers were interviewed about their present use of the science kits, any prior training they had attended on science kits or inquiry science teaching, and what they hoped to accomplish for themselves during the 4-day workshop. These seven teachers were also asked to talk about how they taught science in their classrooms and their ideas about inquiry science (see Appendix for interview questions). These seven teachers were those who agreed to participate in an interview when all the prospective attendees for the summer workshop were contacted to request an interview. The focus-group teachers represented teachers from all districts in the project, as well as teachers from a variety of experience levels. During the first 2 months of the school year, about 1 month after the workshop, six of the seven focus-group teachers were interviewed again; one of the teachers was not available for an interview. They were asked to discuss their views on (a) the workshop, (b) working with the scientists, (c) the real-world scenarios, (d) what they felt they had learned during the workshop,

(e) what they would liked to have done during the workshop, and (f) how their experiences at the workshop had affected their teaching of the kit.

Classroom Observations. Five of the six teachers involved in the postinterview had observations conducted in their classrooms. The sixth teacher did not use the science kit in her classroom until after the semester following the classroom observations, so no observation was made in her classroom. These observations were made by Morrison during the teachers' implementation of the science kits. Observations were conducted over a 1-month period at the beginning of the school year following the summer professional development. During the observations, data were specifically collected on the following: teachers' references to the specific scenario experienced in their summer training, scientists, inquiry science, or science content relevant to the real-world scenario.

Data Analysis

Interviews. After all interviews were transcribed, data was analyzed by analytic induction (Bogdan & Biklen, 1998). Patterns of similarities and differences in perspectives and approaches and any changes in these perspectives for each of the research questions were sought. Categories created included teachers' references to (a) the science content being learned, (b) the scientists as teachers or researchers, (c) the real-world scenario as a learning situation, (d) changes in their own content understanding, (e) changes in their pedagogical knowledge or practices, and (f) reasons the workshop was successful or unsuccessful.

Surveys. To determine participants' learning gains based on their understanding of the underlying concepts of the specific unit, their ability to teach the content using the teachers' guide and their confidence in how prepared they were to teach the kit, the means of the pre- and post survey scores, as well as the standard deviations, were calculated. The effect size was then determined. According to Orlich (1996), the effect size is calculated by subtracting the mean score of the pretest from the mean score of the posttest and then dividing the difference by the standard deviation of the pretest:

> *An effect size of 1.0 can be interpreted as a gain of one standard deviation on a normal curve for the treatment group. An effect size of 2.0 is phenomenal. At 0.3, an effect size becomes useful or important. Effect sizes of less than 0.2 are usually not important. An effect size of 0.25 begins to show importance. (p. 76)*

The comments participants made on the postsurvey and the post-postsurvey were analyzed according to the categories generated through the interviews.

Observations. The observations conducted by Morrison were videotaped and transcribed. The transcriptions were analyzed for evidence of teachers' references in their discussions with students of any of the categories previously established (i.e., references to science content, to scientists as teachers or researchers, or the real-world scenario as a learning situation). The transcriptions of the classroom observations were also analyzed for evidence of teachers' discussions with students any of the following categories: use of the science kit to learn science, inquiry investigations relevant to the topic, or the summer professional development experience the teacher had completed involving real-world scenarios. It was important to establish if the teachers carried anything into their classrooms from the scenario investigations presented by the scientists.

Other Data Sources. Data collected through field notes, observations of the scenario sessions, and feedback from the scientists were all used to inform, refute, and support findings from the other main data sources. These minor sources were analyzed for evidence or contradictions relevant to the categories defined above.

Findings

Teachers' Perspectives

The first research question in this study focused on how the teachers responded to and how they felt they learned from a professional development project involving instruction by scientists and real-world scenario investigations. The 47 teachers attending the professional development workshop self-rated for science knowledge and teaching skills on a 4-point scale (*1* = low, *4* = high) in three categories on both the pre- and postsurvey. The categories and the averaged score for pre- and postassessment (Table 1) show that the teachers rated themselves slightly higher in each category after the workshop. The effect size was calculated to be 0.94, approaching a gain of one standard deviation on a normal curve for this group of participants.

Perspectives on the Scenarios. To get an idea of how teachers felt about this professional development project in terms of the real-world scenarios, the teachers' responses on the surveys and in the interviews were analyzed, as well as any comments collected during observations of the workshop. The teachers all felt that

Table 1
Pre- and Postsurvey Results

Assessment categories	Presurvey	Postsurvey
My understanding of the underlying concepts of this unit	2.58	3.43
My ability to teach content using the teacher's guide	2.47	3.59
My confidence in how prepared I am to teach this unit	2.34	3.40

Note. *1* = low, *4* = high.

they learned new content and built understanding during the 2 days they spent with the scientists. One teacher commented on the survey “I learned so much about what I did not know but thought I did!” Another wrote on the survey “My depth of [electronics] . . . (knowledge) has really grown. I knew the book knowledge, but the hands-on experimenting was wonderful.” The confidence gained by another teacher is apparent in the survey comment: “I knew NOTHING about electronics, and now I do.”

Many teachers reported that, because they could not use the scenario investigations in their own classrooms, they would rather have spent time on activities more closely related to the specific kits. “The group collaboration was great, but it would have helped to have the scenario from the kit itself” was one teacher’s comment. Another said that “Adult learning is important, but I don’t know if the specific scenario helped. I can’t tell if it will be useful when teaching the kit.” The teachers thought that having a chance to go through a scenario from the kit itself would have better prepared them to teach the material.

> *I would have done one of the scenarios from the kit itself so you could actually do a run through as to what the kids are going to experience and the thoughts and feelings they’re going to have . . . Because you . . . have to think it through and come up with ideas. I think it would be helpful to do one you could actually present. (postinterview)*

Although some of the teachers voiced concerns that they could not use the scenario in their own classrooms, all the teachers mentioned that investigating and collaborating while completing the scenarios were important for their own learning. “The guided-discovery circuit exercise worked very well to excite and educate me” was one teacher’s comment on the survey. Another stated “The hands-on part was intimidating, although I realize that the point of it was to force us to get over our fears.” Many of the teachers reflected that they were being required to become learners faced with new content.

> *I think it (the scenario) was worthwhile because of how it put you in the situation and reminded you of how you need to be as a learner and how to present it better. I thought the training was good. I think you still just need to get in and do it. (postinterview)*

> *Learning new concept(s), hands-on practice, having teachers with experience around was the best thing about [the professional development]. (postsurvey)*

The teachers made comments that, although the inquiry-based investigation was difficult, it challenged them and was beneficial to their learning about inquiry science:

I was really excited about these 2 days. This was the first time that I had been involved in something that linked my teaching to "real" work, and it was refreshing . . . Once I got past the discomfort of being confused, that is. I learned a lot! (postsurvey)

I must admit that the 1st day was spent in total confusion (by me). It appeared to me that those teachers around me knew everything there was to know about electronics concepts, but I knew nothing. I just assumed that there was this giant hole in my science education that didn't include any electronics understanding whatsoever. After having successfully completed the workshop, I could see that this 1st day was one of "inquiry," and I wasn't used to this approach. I was out of my comfort zone . . . big time. (post-postsurvey)

Many of the teachers remarked that spending 2 days on the specific scenarios was too much because they felt they needed more time to go through the specific kits they would teach in the fall. Representative responses from the teachers were "The activity (scenario) could have been shortened, additional time to train using the kits would be useful" and "The scenario was great but 1 more day with the kit would have helped." The teachers may have expected more specific kit training and felt they were not accomplishing their objectives by having to spend 2 days on the scenario session. When asked for suggestions for future trainings, many of the responses were on timing: "Perhaps more time to actually do kit activities," "Time to set up one lesson from start to finish," "More kit or all kit and more time on each investigation," and "I would like the kit training first and the group training second."

Perspectives on the Scientists. The majority of teachers commented that the scientists were very knowledgeable in their fields and helped the teachers gain a better understanding of the content. The teachers said that they liked having a chance to hear from someone with experience and they enjoyed being taught again "at the college level." The scientists involved in this professional development were sincerely involved in the teachers' struggles to learn the material:

As an engineer, Bob tends to go off on tangents way above the average teacher's head . . . What can you do but laugh and point out to him that he just quantum leaped past you . . . He does have a great way of making you feel comfortable with your lack of knowledge and listening carefully to concerns. (post-postsurvey)

Watching the teachers in the class—at first they were a little nervous around him, but quickly gave way to comfort as they saw he was genuine in his concerns and patient about explaining. (lead teacher's comments collected in Morrison's log)

Survey comments from the teachers focused on their frustration at the depth of the science vocabulary used by the scientists and the speed of the delivery, "My only suggestion would be to cover the vocabulary a bit more, especially with those of us who are not science majors." When asked for suggestions to improve future professional development opportunities on the survey, two responses regarding science terminology were recorded. The first teacher said, "More opportunity to go through the labs on our own, AND THEN have the chance to ask the experts for clarification. Go over, review, and learn vocabulary relevant to unit before starting." The second teacher commented, "Great workshop! My only suggestion would be to cover the vocabulary a bit more, especially with those of us who are not science majors."

Perspectives on Teachers' Own Background Knowledge. Some of the teachers involved in the workshop were going to be teaching science content they had not previously taught and were, therefore, participants in a session where they had little content background. This added to their frustration level. One representative survey comment was "I did not have much technical background and got 'lost' as soon as the technical language was used." Another said, "The speed of covering the material at times was a bit quick for a novice in this field of study (electronics)." One teacher involved in the life science scenario expressed frustration at her lack of knowledge on the content covered in the scenario and the peer mentoring that occurred when teachers of different abilities were in the same scenario session:

> *Well, had I been a life science person, it would have been more beneficial, but someone coming in who has had maybe . . . a year of biology—and that was a long time ago! And this guy was going into things that people in CSI are doing! . . . It was over my head! I felt like a total idiot the whole 2 days, a total idiot. If it hadn't been for (fellow teacher) who is a life science person . . . I probably would have cried every night because it was so frustrating! And I know that they wanted to put us back to feeling like a student . . . Just going through the kit, I felt like a student because of the questions and the inquiry and everything that's designed. (postinterview)*

Another teacher commented in the interview on the frustration observed in others doing the electronics scenario session: "I saw people get so frustrated because it was very high-level stuff we were dealing with. They got so frustrated that they kind of shut down."

Aspects Implemented

To answer the second research question about what aspects of this type of professional development are incorporated into these teachers' science teaching, the teachers were observed using the specific curricula and also reported in a post-postsurvey on how they had implemented various aspects they gained during the first 2 days of the workshop. The general feedback provided by the teachers after they had taught the kits in their classrooms was that the scenario investigation had allowed them to experience inquiry as their students do for the first time, as well as provide their students with support as they struggle with content understanding. The scenario investigation provided the teachers with science content and served as a model for teaching the content. For example, one teacher reported in the post-postsurvey that "Student kit activities became more meaningful to me because of this extra assignment that went beyond what the kit expects me to do." Other representative quotes from the teachers demonstrate that, as they reflected back on their teaching of the kits, they felt the scenario investigation had benefited them.

> *It forced me to really question what I truly knew about capacitors and their role in a electronic device . . . Talk about ratcheting up the learning curve on my part . . . I can now safely state that I truly understand the working of a capacitor . . . As a result of the experience, my students have benefited also . . . both in knowledge content and my empathy for them as they start out on the electronic kit and learn about all the new components. (post-postsurvey)*

> *The real-world scenario was a model for me to teach as a "guide on the side" when students have big challenges like this instead of answering their questions. So, whether or not [he or she] was a scientist, the presenter did an effective job of using a real-world challenge to impact my teaching by modeling effective guidance through a discovery application project. I can take back that experience and apply it to my students as I use this kit and other teaching, as well. (post-postsurvey)*

> *I appreciated seeing some of the equipment used for DNA analysis. It makes it much easier to explain to students. (post-postsurvey)*

None of these teachers were seen to conduct any classroom discourse with students about the content or processes in which they had been involved during the scenario sessions. During the classroom observations, references to the real-world scenarios were looked for, as well as any reference to the nature of science, how science works, what scientists do, or the teacher's specific experience doing the real-world scenario. None of the teachers observed referred to any of these topics during the classes observed. It is possible that, during classes other than those observed, the teachers may have made comments to their students on these topics.

Discussion

The data collected in this study show that the 47 middle school science teachers did gain beneficial knowledge during the 4-day professional development workshop. These teachers all felt that they knew more about both the science content included in and the implementation of the kits after the program. The critical question being investigated was whether this type of professional development involving scientists would be perceived by teachers as contributing to their growth in content knowledge and process understanding. We saw that this was indeed accomplished: the participating teachers felt they had accomplished growth in both content understanding and process skills. It was hoped that the scientists would not be seen as experts removed from the concerns of the typical middle school classroom, but as mentors that could help the teachers translate the science content and facilitate the teachers' understanding. From teachers' comments about receiving professional development from the scientists, we saw that the teachers felt comfortable with the scientists and appreciated their expertise. The teachers did not consider the scientists as "outsiders." This, in itself, was seen as a major positive outcome of the study. This feeling of comfort with the scientists was possibly due, in part, to the personalities of the scientists involved: They were all approachable and concerned with public school education. The scientists were treated as experts by the teachers during the scenario sessions due to their obvious understanding of the science content being presented. Therefore, the scientists and teachers were not equal partners in an endeavor to construct educational experiences for students. For this to occur, the teachers would need to be held up as experts in teaching and learning, as the scientists were presented as science content experts. This is in line with Darling-Hammond and McLaughlin's (1995) recommendations that professional development must be collaborative by focusing on communities of practice.

The teachers did voice concern about the unfamiliar vocabulary and the high-level content used by the scientists and suggested that more introduction to terminology would have been helpful to them. The terms that the scientists used in their everyday speech were often unfamiliar to the teachers, and the scientists did not recognize this until the teachers requested clarification. This could signify a lack of pedagogical expertise in the scientists; they were not reflecting on students' current knowledge as teachers (we hope) do when new material is presented. The curricula covered in this professional development were new to all but four teachers who had piloted the kits during the adoption process. This unfamiliarity with the curricula would certainly leave teachers with little knowledge of the terminology involved in these science areas. The teachers who were training in a new content area certainly were unfamiliar with the vocabulary used by the scientists. This struggle with the vocabulary, therefore, was symptomatic of unfamiliarity with the content. It is possible that the teachers' concerns about unfamiliar vocabulary were a symptom of their weak content understanding.

Observations of the scenario sessions and feedback from the teachers demonstrated that the teachers mentored each other when there was a lack of terminology knowledge. Those teachers with better understanding consistently helped their peers with less mastery of the terms used by the scientists. This aspect of the professional development experience was not planned or specifically encouraged; because most of the work was completed in cooperative groups, this collaboration among teachers allowed those teachers with less content knowledge to benefit from their peers' deeper understanding.

The scenario investigations designed by the scientists captured most of the teachers' interest and the majority felt invigorated by the new learning experience.

Some of the teachers mentioned that these investigations frustrated and often intimidated them, but allowed them to gain a significant amount of new content knowledge and acquire an insight into how science is conducted in the real world. This insight was a key reason for connecting scientists and teachers. Also, the teachers' confidence regarding their understanding and teaching of the specific science content improved (as evidenced by the postsurvey scores). As discussed by Czerniak and Lumpe (1996), an improvement in a teacher's self-efficacy will have positive effects on his or her implementation of reform strategies.

The teachers commented that the scenarios took more time than they would have liked. Many of the teachers expressed that being trained to use the curriculum materials was a higher priority than spending time on materials not directly related to the kits. The feeling that they needed time on kit training, rather than time involved in an investigation, was prevalent in many of the teachers. They felt the pressure of implementing a new curriculum and wanted time to learn how to manage the new materials. If the scenario investigations had been presented after the training days, the teachers may have felt less stressed regarding time.

During the classroom observations, none of the teachers made any reference to the real-world scenarios or the nature of scientific inquiry. Certainly, to assess how the teachers were communicating this broad subject to their students, daily classroom observations over a longer period of time would need to be carried out. A one-time observation would not support any general conclusions. Also, if the real-world scenarios had been adaptable for use in the teachers' classrooms, then the teachers may have been observed using the scenarios when teaching the science content presented during this professional development project.

In addition, as researchers (Bryan & Abell, 1999; Tobin et al., 1994) have stressed, teachers' beliefs about instructional strategies and student learning strongly impact their decisions on how and what they teach. In the scenario workshop, the teachers' beliefs about inquiry teaching were not the focus. Teachers were involved in the inquiry investigation, but their ideas about inquiry were not specifically addressed. Therefore, it is possible that, by failing to address their beliefs, the workshop did not fully support teachers' implementation of inquiry science.

Recommendations

Our initial question was whether or not scientists could enhance a professional development workshop for middle school science teachers. It was seen that introducing the scientists to the teachers and encouraging them to mentor the teachers was positive for the teachers. The teachers in this professional development project certainly did not see the scientists as remote experts removed from the concerns of the classroom (Loucks-Horsley, et. al., 1998). The only disconnect seen was the use of vocabulary by the scientists that was not understood by some of the teachers. In the future, in similar situations, we would like to see a discussion of terminology be part of the design process of the professional development experience. The scientists needed to be told that there may be a gap between their conception of a common term and the teachers' knowledge. This type of pedagogical content knowledge would allow the scientist to be able to incorporate definitions of these terms into the scenario presentation. Teaching something for the first time usually uncovers all sorts of things that are corrected the second time around.

During future professional development activities, it will be important for the scientists and teachers to generate lists of terms that they have used and make certain these are understood clearly by all participants. This would alleviate the teachers' frustrations with vocabulary they do not know. It will be important for someone at the same level as the anticipated workshop audience to recommend terms needing to be defined by the scientists; identification of terms problematic for teachers may be difficult for a scientist who uses the terms in daily language. It will also be important for the scientist providing the training to be aware of the knowledge and experience levels of the teachers involved in the training. One method to accomplish this might be to ask participating scientists, in collaboration with a lead teacher, to prepare an informal, nonthreatening questionnaire on teachers' prior knowledge to administer prior to the professional development. Asking for some type of self-identification of content understanding from novice learners might allow the scientists to monitor the learners' understanding as the professional development progressed.

Certainly, including a teacher leader experienced in the pedagogical content knowledge of the topic in a discussion of the participants' possible levels of understanding is recommended. Although in this project we held a meeting between scientists and one teacher leader prior to the professional development, this was not set up as a time for the teacher leader to discuss the pedagogy of the scenario sessions. To provide opportunities for the scientists and teacher leaders to discus, in depth, the science pedagogy needed for a scenario session, such as those discussed here, the planning would need to occur over time; and, after each scenario session, the planners (scientists and teacher leaders) would need to meet to debrief and plan future sessions. If the personnel planning the scenario sessions (scientists and lead teachers) can remain constant over time, then the lessons learned from each professional development should help to improve the next session. As stated by Darling-Hammond and McLaughlin (1995), effective professional development must be collaborative in nature and focus on teachers' communities of practice, rather than individual teachers.

In future professional development trainings where scientists are used as mentors, it will be important to design scenario investigations that are more applicable to the actual curriculum materials being introduced. "[Professional development] must be connected to and derived from teachers' work with their students" (Darling-Hammond & McLaughlin, 1995, para 4). If teachers are involved in an inquiry investigation that allows them to learn relevant content and also provides them with ideas and activities useful for their own classroom, then the time will be well spent. When involving scientists in the professional development of teachers, it may be necessary to have scientists and lead teachers design the professional development in partnership. The scientists will need to understand the curricular materials and their implementation, and the lead teacher will need to understand the science knowledge and processes of the relevant content to design a significant professional development experience for participating teachers. As discussed by Supovitz and Turner

(2000) as one of the critical components of high-quality professional development, "Staff development undertaken in isolation from teachers' ongoing classroom duties seldom have much impact on teaching practices or student achievement" (p. 964). This is in line with Garet, Porter, Desimone, Birman, and Yoon's (2001) findings that programs most likely to produce enhanced knowledge and skills in teachers are sustained, are focused on content, involve active learning, and are integrated into the daily life of the classroom. Certainly, all learning situations should not have to be directly translated to classroom usefulness, but a combination of infusing new content knowledge and providing classroom applications would be optimum. It is also important for teachers to be able to gain insights into the world of the scientists, to get a taste of the real science as it may be conducted in the research world (Loucks-Horsley et al., 1998).

One aspect of this professional development project that surfaced as a positive outcome was the feedback from a number of teachers about the excellent collaboration that occurred among the teachers themselves. Although this was not stressed in the initial discussion of the scenario sessions, many of the teachers depended heavily on their peers' understanding of science in areas where they were weaker. In future sessions, it will be important to stress this aspect of professional development; scenarios will be designed to facilitate teacher collaboration to maximize teachers' learning from each other.

To affect teachers' beliefs about inquiry science and, thereby, their implementation of inquiry-based teaching, specifically addressing what inquiry is in professional development offerings will be essential. In future workshops, such as the one described here, it will important to spend time discussing with teachers the nature of scientific inquiry, the basis of teaching in an inquiry manner, and the research supporting the use of inquiry practices. It is hoped that, by allowing teachers to learn about, discuss, and reflect on the aspects of nature of science and scientific inquiry, their beliefs about and use of inquiry science will be impacted.

We found using scientists and real-world scenarios an effective strategy for encouraging middle school science teachers to teach science as a process and help them strengthen their science-content understanding. The participating teachers were motivated to get into their classrooms and teach the content they had learned; and the scientists involved expressed a heightened interest in, and understanding of, how science is taught in the public schools of their area. The way to develop more successful sessions will be to build subsequent sessions from those presented. We realized that our first attempt was only a beginning, and we plan to build on the lessons learned from these first scenario sessions presented.

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Appendix

Interview questions: LASER research

LASER experiences:

1. List and describe any experiences you have had with the LASER program (SPI, YV/TC, districtwide trainings, etc)
2. Describe any science kit/module trainings that you have been involved in.
3. Describe any other LASER professional development experiences in which you have been involved.
4. Describe your school's involvement in the LASER program. Describe your district's involvement
5. What have you seen at your school or at the district level that has occurred due to the LASER program?
6. Describe your role in the LASER SE Regional Materials Center curriculum adoption.

Nature of Science/Teaching Science

1. What is science? Can you describe what it means to you?
2. Do you think of science as a process? What does that process look like?
3. How do you feel is the most effective way to teach science?
4. How do you convey science concepts to your students?
5. Define inquiry-based science teaching.
6. What would an inquiry-based science lesson look like in your classroom?
7. How do you know if a student understands a science concept?
8. What are things that you look for in students when checking for understanding?

9. What strategies do you use to assess your students' learning of science?

Kits/Units

1. What is your reaction to using science modules to teach middle school science?
2. Are there any benefits to using the science modules?
3. What are some of the concerns you have with using modules to teach science?
4. If you don't have prior experience with or knowledge of the science content in a specific module, what do you need to gain this?
5. What do you need to know or have before teaching a science module?
6. What resources might you need while teaching with a science module?
7. Describe the science content you might need to teach the module you have been assigned. How confident do you feel about this content?