Teacher Collaboration across and within Schools: Supporting Individual Change in Elementary Science Teaching

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ABSTRACT: The purpose of this study was to develop an understanding of how collaboration among teachers from several schools, and with university researchers, facilitated these elementary teachers as they attempted change in their practices. The collaboration effort was built into an in-service project for elementary teachers that focused on assisting teachers to implement a curriculum emphasizing problem-centered learning in science. The project involved 24 teachers in a 3-week summer workshop and an intensive follow-up research program during the following school semester. Our understanding of the relationship between change and the collaborative experience was developed from multiple data sources, including transcripts of interviews and group meetings, lesson plans and other teacher produced artifacts, and field notes from classroom observations. Our analysis of the data indicates that collaboration facilitates change because it provides opportunities for teachers to learn both content and pedagogical knowledge from one another, encourages teachers to be risk takers in implementing new ideas, and supports and sustains the processes of individual change in science teaching. © 1997 John Wiley & Sons, Inc. Sci Ed 81:51–65, 1997.

INTRODUCTION

The quality of science instruction that elementary students receive has long been a concern of educators (Carnegie Forum on Education and the Economy, 1986). Studies on how science
is being taught in schools leave no question that change is necessary (Manning, Esler, & Baird, 1982; Morley, 1990; Tobin & Gallagher, 1987). In an effort to guide change in what happens in science classrooms professional societies of scientists and science educators have developed *National Science Education Standards* (National Research Council, 1996), which outlines what teachers of science at all grade levels should know and be able to do as well as a vision for the development of professional knowledge and skill among teachers. However, as this article will show, change is a slow process and must be supported at all levels to be successful. Sustained classroom change is not likely if new standards are simply imposed upon classroom teachers (Richardson, 1990).

Change involves restructuring fundamental beliefs and ideas that teachers have about what is important for students to learn and how materials and methods may be used so that learning is achieved (Fullan, 1982, 1991). It is a painful process that involves emotional struggle (Tobin, Briscoe, & Holman, 1991). The subjective realities that teachers have constructed regarding their work within the cultures of their schools are not conducive to the assimilation of new methods into practice. If change is not introduced in a manner that takes into account teachers’ concerns regarding how the change will affect them personally, it is likely that implementation will neither be successful nor sustained.

Investigations of how collaboration among teachers and researchers influences the development of individual teachers as they implement change (e.g., Briscoe, 1991a; Connelly & Clandinin, 1988; Day, 1987; Hargreaves & Dawes, 1989; Miller, 1990; Tripp, 1987) suggest that interaction among teachers is primary in facilitating the change process. As Fullan (1991) notes:

> There is no getting around the *primacy of personal contact*. Teachers need to participate in skill-training workshops, but they also need to have one-to-one and group opportunities to receive and give help, and more simply to converse about the meaning of change. (p. 132)

Fullan argues that when teachers are able to interact with one another change is facilitated. Collaboration increases teachers’ ability to analyze and improve classroom practice and is a factor in increased job satisfaction.

The intent of this study was to develop an understanding of how collaboration among teachers from several schools facilitated these elementary teachers as they attempted change in their practices. The study attempts to answer questions regarding the nature of the change process and how individual teachers may be supported in changing the way they teach science through peer collaboration within and across schools.

The project was designed to assist elementary teachers to plan and implement change in their curriculum to emphasize problem-centered learning in science. The plan for implementation of the project was based on constructivist perspectives on learning and change. Constructivism (von Glasersfeld, 1989) implies that, as teachers engage in learning which may lead to change, new ideas and experiences are interpreted and tested for viability in terms of what is already understood about teaching, and what works in the social and cultural milieu of the educational community. Any change in the implemented curriculum will fit the teacher’s understanding of what makes sense in a given context (Briscoe, 1991b; Tobin, 1993; Tobin & Ulerick, 1989).

Because change occurs in a social context, it is influenced by interactive processes between teachers as well as the personal learning process. The strong influence teachers have on one another’s perceptions regarding classroom change, and whether it is to be valued, make it particularly important that teachers find support for change among their peers (Briscoe, 1991b; Feimen-Nemser & Floden, 1986).

Accordingly, we attempted to recruit teachers for the project as pairs, by grade level, from each school. In this way, each teacher would have at least one in-house colleague to share
planning activities and to provide support during the implementation process. Additionally, as part of the fall implementation, monthly meetings were scheduled to provide the teachers from all schools an opportunity to meet as a group. These planned opportunities for collaboration among the teachers had the potential to foster reflection on what happened as changes were implemented and to enhance their understanding of new practices (Elliott, 1980; Hollingsworth, 1992; Hunsaker, & Johnston, 1992; Nias, 1987). Furthermore, they could serve as a beginning for analyzing and overcoming perceived cultural constraints to change (Peterman, 1993).

THE PROJECT

Selection of Participants

The project involved 24 elementary teachers from a single district, 2 science education professors, and 2 graduate research assistants. The selection of teacher participants was a cooperative effort arranged between the university faculty, the district science/math supervisor, and individual school principals. Teachers at each of the 13 elementary schools were provided with an outline of the project and its goals, and asked to contact their principal if they wished to be considered a candidate for selection. Seventeen teachers representing ten schools responded. Unfortunately, the recruitment resulted in school/grade-level pairings in only five cases (ten teachers). After we recruited additional teachers recommended by participants our final group consisted of six paired teachers, five teachers who were the only representatives from their schools, and seven teachers who were from schools where there were other participants but not at the same grade level.

The Summer Program

The initial phase of the project was a 3-week summer workshop. Teachers met 4 hours a day, 4 days a week. Although an outline was provided to each teacher on the first day, suggesting an agenda for the workshop, the implemented agenda for this initial phase was negotiated by the participants and the university team. In this way goals were set by consensus and power was shared (Goodlad, 1990). No one facilitator or participant was seen as “in control.” Through the negotiation process teachers provided suggestions regarding the type of instruction they needed to be able to plan for problem-centered learning and set the conditions needed to make planning possible.

It was decided that the university team would provide instruction to the teachers on constructivist perspectives of teaching and the nature of problem-centered learning. To a lesser degree, use of the computer in problem-centered activities and the use of alternative assessments in evaluating learning based on problem solving were also discussed and modeled. An important feature of the instruction was the use of problem-centered activity examples. Activities were set up to enable teachers to experience, themselves, the nature of a problem-centered lesson. The teachers were challenged to generate knowledge through scientific inquiry that began with the posing of a problem by the university faculty or by the teachers. As the teachers invented their own ways of attacking and working out problems they were encouraged to exchange points of view and to think about and evaluate what they were learning and how they were making sense of their activities.

The activities were set up as centers so that teachers could use the time each day as they chose, working on problem-solving activities or designing and planning problem-centered activities. Many of the activities we set up were reworked by the teachers so they could be
related to the curriculum they already had in place at their schools. The university team acted as a resource throughout the process, providing input, when invited, and assisting teachers to reflect on the nature of the activities they designed and why they were developed as they were.

**Fall Follow-Up Program**

Each teacher was visited by one or more members of the university research team twice a month. The primary purpose of the visit was to observe the teacher as he or she taught science. Occasionally, at the invitation of the teacher, team members assisted the teacher in the class activity. The visits were arranged to provide at least an hour for the teachers and researcher to discuss the progress each teacher perceived herself/himself to be making, the problems he or she faced, and to share ideas. Additionally, one Saturday each month, September through December, was set aside to bring the whole group together at the university campus.

**RESEARCH METHODS**

**Data Sources**

Data sources included transcripts from structured interviews with each participant conducted at the beginning of the summer program, transcripts of discussions between teachers and individual members of the research team during the school term and the Saturday meetings, and teacher’s written self-reports regarding how their thinking was evolving as they planned and implemented curriculum change. Two collections of artifacts were created by each teacher, one which represented the nature of science teaching and learning in his or her classes the previous year and one reflecting implementation of problem-centered activities. These collections, which included examples of lessons taught, children’s work, lesson plans, and assessments served as data and as resources for reflective conversations (Miller, 1990) through which teachers explicated their beliefs regarding teaching and learning. Field notes from classroom observations and group meetings, together with analytical memos generated from them, also served as data sources. Data from classroom observations were triangulated with data from discussions with teachers and from their artifact collections to develop a sense of the direction and extent of each teacher’s individual change.

Our understanding of how the collaborative experience influenced individual change in science teaching is presented in case studies of six teachers, from four of the ten schools, selected because their individual experiences best represent the “unity of the experience” (Stake, 1988) we found across cases. Four of these teachers, Jean, Sue, Becky, and Gretchen, make up two of the five paired teams. Their cases exemplify our understanding of how the within-school collaborative experience facilitated change in science teaching.

Elaine and Helen, like five of the other teachers, did not have in-school colleagues. The cases of these two teachers helped us understand how providing opportunities for teachers to share the collaborative experience through the monthly meetings supported their efforts to incorporate increased opportunities for their children to learn science into their curriculum.

Helen and Elaine were selected because they were experienced teachers who had not been particularly oriented toward activity-based science, but became very actively involved in planning and using activities after the summer program. Elaine teaches third grade. She has 14 years of experience. Her favorite area of the curriculum is language arts and she has generally
taught science through language arts activities. Helen also teaches third grade. She has 8 years of experience and also focuses on language arts.

Jean who has taught 9 years and Sue who has 15 years of experience are third grade teachers. They were selected because they were experienced teachers and because initial interviews and their portfolios indicated they were very different in their teaching styles. Jean enjoyed teaching science and often involved students in group activities at centers. Sue, on the other hand, did not like the noise generated in group activities and provided activities that were more individualized. Their cases helped us understand how important collaboration is for encouraging teachers with well-planned science programs to take risks and develop new kinds of learning experiences for their students.

Becky and Gretchen are fifth grade teachers. They were selected because they are in an early phase in their teaching careers (less than 5 years experience). Although Gretchen has taught science, she described most of her activities as teacher directed. Becky did not like teaching science. She described the year prior to the project as “terrible” and “very boring” for the children. Their cases helped us understand how collaboration can foster growth in both pedagogical and content knowledge that facilitates desired change in science teaching.

Research Design and Data Analysis

The research design for this study is interpretive (Erickson, 1986). What was learned was informed by our experiences in the field and continuous collection and analysis of data throughout the study within a hermeneutic circle. We endeavored to find out the participants’ perspectives of the meanings of change and the collaborative experience. The analysis process consisted of reviewing and comparing the data sources and constructing case studies, looking for patterns and regularities which reflected the nature of the change process and the collaborative experience (Stake, 1988). As the data from selected case studies were analyzed, tentative assertions addressing the research questions were generated (Erickson, 1986). Additional data were collected to test the assertions and all data were classified as supporting or refuting each assertion. The opportunity for field observation over a prolonged time provided an opportunity for us to observe typical classroom behavior of students and teachers, and to establish rapport and build the trust necessary to understand and interpret the contextual meanings of teachers actions.

Member checks (Guba & Lincoln, 1989) were a regular part of the research process. All developing assertions and data were shared with the teachers at monthly meetings. In this way, the teachers were able to respond to the assertions, agree or disagree with them, and suggest corrections. Assertions and teachers’ responses served to guide continued data collection. Through an iterative process of data collection, analysis, and continued data collection, assertions were broadened to encompass all data.

INTERPRETATIONS

The data suggest areas of investigation as they relate to the nature of the change process. These include initial concerns, envisioning the change process, and implementing the change.

The Teachers and Their Concerns

The 24 teacher-participants ranged in experience from 2 to 25 years. Six had 5 or less years of experience, whereas eight had over 20 years of experience. Average years of experience among the teachers was 12 years. Nine of the teachers had master's degrees.
During the initial interview teachers were asked their favorite area in the curriculum. Only six responded that science was an area they particularly enjoyed teaching. Each teacher also was asked to imagine what his or her teaching would be like if he or she had no constraints. The teachers’ responses to this question provided a sampling of their concerns. Most teachers noted a desire to provide more hands-on activities, but cited limitations due to lack of sufficient budget for supplies. Five of the teachers noted that they taught in portable classrooms without water and without much storage space. Another frequently mentioned constraint was time. Teachers felt there was not enough time to prepare to teach science nor teach it in a hands-on way because of other curricular demands.

On a more personal level, two other factors that influenced how these teachers taught science were lack of science knowledge and lack of pedagogical knowledge to implement more open science investigation. Most of the teachers noted that they did not have strong backgrounds in science and it was difficult for them to design classroom activities for science beyond those that appeared in the textbook or in other resources that the county supplied. Several teachers noted a fear of losing control of students if they were given freedom to explore science ideas through problem-centered learning. As Rebecca noted:

Well, if there were not the problem of feeling like you were losing control, you know, the problem-centered science would be absolutely wonderful. It’s just as a teacher it’s really hard to say, well, you’re going to do it for yourself. It’s so much easier to say this is the answer. . . . It’s hard to let go.

Although these teachers understood the importance of hands-on experiences for children’s learning, the constraints they identified, either perceived or real, created an environment in which they felt powerless to make changes.

These concerns are not uncommon among teachers at all levels and in all areas of the country (Huberman, 1980). They are among the factors that cause teachers to view change as a pointless additional effort in an already impossible context. However, many of the teachers participating in the project were able to find means to overcome constraints as they worked together.

**Conceptualizing Change**

All of the teachers described an ideal model for teaching science that was different from the one that was represented within their portfolios and described in the interviews. These teachers indicated that, historically, they had relied heavily on the textbook in planning science. Prepared worksheets, teacher-directed, hands-on activities and publisher’s tests were common to nearly all portfolio collections. Teaching science seemed to mean covering units from the book or developing single topic units using other available print resources. Most teachers noted that they did centers or experiments that were hands-on when they could; however, open-ended or problem-solving activities were not apparent. The following comments are representative:

Jean: I teach the way the rest of my school teaches. We read the chapter, we do worksheets, answer questions, we take tests. Pretty standard, pretty routine, pretty ordinary, I guess. I also like to fill in with centers. [personal interview]

Rebecca: We mainly go by the book and read everything and get all the information . . . Then
we do things like a model . . . making things to go along with it which I feel like they’re learning through that. [personal interview]

However, at the end of the summer project, teachers described changes in their thinking about how science could be taught. Each teacher had designed at least two problem-centered activities to submit for a booklet that was provided as an outcome of the project. Because we strongly emphasized integration of curriculum and provided examples of how science, mathematics, language arts, and social studies could be part of a curriculum that included problem-centered learning, the teachers began to think about teaching science within an integrated curriculum. Considering science problem-solving as allowing them to teach science, not in isolation, but across content was clearly a new way of thinking about teaching for the participants. The following comments regarding how teachers’ thinking had begun to evolve are representative:

Sue: I feel that I have been set free from the constraints of teaching a unit on a subject at a given time. Approaching science in the way we have these last 3 weeks, is so much more exciting and I’m really chomping at the bit to get started. Even planning for it is more fun than my old way of doing science. [self-report]

Helen: The basic idea of coming up with problem-solving activities was like this revelation that seems so obvious that you don’t have to teach a unit from beginning to end, you know the entire solar system in one unit in a 2-week period, that you could do bits and pieces and just connect it to other things you’re doing. [personal interview]

Within an environment that facilitated and supported the teachers as they planned for integrated problem-centered learning in their classrooms, the teachers had begun to reconceptualize science teaching. The opportunity to plan together, to share ideas, and to discuss with one another alternative ways of teaching had facilitated this initial change.

Implementing Change

Having constructed new ideas about teaching and methods for delivering instruction as a result of teacher education programs, participants generally depart intending to implement change. However, within the contexts of their own classroom and the culture of their schools, where support for change is not necessarily consistent with the teachers’ newly constructed beliefs, it may be difficult to act in accordance with them.

In this study, we observed that most of the teachers were willing to experiment with problem-centered learning in their classrooms. The fact that we were going to observe them may have encouraged these first attempts, but support offered by other participants and the university team also were factors in the continued use of problem-centered activities by many teachers.

There were many variations in how teachers incorporated problem solving. For some teachers, problem-centered activities were only used occasionally as enhancements to regular classroom instruction. Often these activities were selected from those practiced in the summer workshop or from those shared by teachers at the Saturday meetings. For others, complete curricula were planned that integrated problem-solving activities several times a week throughout the fall term.

Although the collaboration among teachers was important in supporting teachers’ sustained efforts to implement problem solving, another key factor that was mentioned by teachers as sustaining their efforts was the encouragement they received from observing how enthusiastic
their children were when given an opportunity to engage in problem solving. The following comments are representative:

Jean: [When] I started, nobody liked science. I had two students that liked science and the rest of them find it absolutely boring. They hated it and they were not looking forward to it at all. As time progressed, now they all love science because it is all hands on. We are all scientists. [personal interview]

Tonya: Its really worked for me in more ways than I can imagine because they’re even coming up with “Why doesn’t this work,” and “Can I go to the library.” They’re ready to do research with this information . . . The biggest thing I’ve found is the excitement that’s there. [Saturday meeting]

COLLABORATION AND CHANGE

Implementation of problem-centered activities teachers had planned involved them in developing new ways of managing the classroom, their time and materials, and their interactions with students and peers. From our studies of individual cases we constructed three assertions that characterize how opportunities for collaboration influenced individual teacher change.

Assertion 1: Brainstorming was an important process that assisted teachers to learn content and pedagogical knowledge from one another. One teaching circumstance common to the all teachers in our study was the lack of opportunities for them to share ideas about teaching and learning with others in their own school. During the school day, the teachers were not likely to be scheduled for any common time together. Therefore, even for teachers on our within-school teams to be able to share ideas they had to set aside their own time after school to work together. Having had the opportunity to forge working relationships with one another in the summer workshop, Sue and Jean and Gretchen and Becky made the commitment to continue collaborating throughout the fall term. The rewards for these teachers in terms of learning opportunities for themselves and their students are reflected in their descriptions of their experiences at these meetings:

Sue: We just really start brainstorming, and I’ll have an idea and throw it out and then she starts throwing them in and we have a real hodgepodge. Then we have to kind of go back and sort out and pull out and decide [what we’ll do].

Becky: We plan everything out and get our ideas together and it makes it so much easier to do things because I feel like I’ve really got it down . . . and you can ask each other questions. Cause if you don’t understand how this works or doesn’t work or whatever, [I’ll ask] what do you think and she’ll give me what she thinks and we’ll put it together and come up with the answer to some of the problems we give the kids and some of them we give the kids are hard. [personal interview]

Gretchen: I can’t wait to sit down and do the science. I do it before I do anything else. [personal interview] I can’t wait to get to school everyday to find out what the kids will do and learn from the problems. [field notes]

For these teachers, who were not accustomed to planning for problem solving in science, the process of brainstorming with a peer was clearly an important process that facilitated change. Although Jean had always taught science with a hands-on approach, she had generally directed the activities with detailed instructions, rather than allowing children freedom to make decisions regarding their science investigations. She noted that brainstorming was important to her as a way to generate problems for the children to solve. When Sue became ill and had
to leave school for several months, Jean noted the profound effect Sue’s prolonged absence had on her own teaching. As she described it:

[When] we were able to get together and brainstorm, it was a whole lot easier for me to think in terms of problem solving because we had that brainstorming going on. Now that it's been a while since we've gotten together . . . I find myself subconsciously regressing back to my old way of teaching. So the earlier activities I planned probably came off better. [personal interview]

**Assertion 2:** Knowing that a colleague would be there to try similar activities and discuss successes and failures provided teachers with courage to take risks they would not otherwise have taken. For Jean, changing her way of teaching science, at least at the surface level of implementation, seemed not to be a problem. She had always used centers, although not with a focus on problem-solving, and was accustomed to movement and noise in her classroom. Field notes from classroom observations indicate that she did involve her students in real problem-solving activities: allowing them prime responsibility for inventing cave paint during the lesson on prehistoric man; developing a means to move stone blocks (by designing their own simple machine) to build a pyramid during the unit on Egypt; and developing a classification system for seeds and plants in their environment during a unit on Native Americans. Jean noted that her greatest problem was assisting the children to believe in themselves as problem solvers rather than asking her what to do and how to do it, something that Jean had accepted as common practice in previous years.

Sue, like Jean, had taught science in a manner that relied heavily on the textbook and the associated worksheets and tests that accompanied it. She attributed her past experiences as a student and teacher as primary influences in formulating her beliefs:

I think that it was when I went to school things were structured. Everybody, in order for someone to learn, they needed to sit still and listen and then do it. . . . That’s kind of the way I was instructed so it just kind of moved on into my instruction. . . . The teachers that I was affiliated with and the schools that I was in, the principals liked the structure when I was teaching. So it just all went together that I was very structured. [personal interview]

As she collaborated with Jean, who modeled thinking about teaching science in a very open style, allowing children to work with materials in a loosely structured but well-managed classroom, Sue began to reconceptualize what her own teaching might be like. She began to give up control a little at a time. Her first experimental change was allowing students to work together in small groups on mathematics and vocabulary review tasks. She noted to the research observer during this activity that, typically, noise created by children working together always bothered her (field notes).

Although Sue and Jean planned their lessons together, Sue adapted the activities to allow her to maintain a more structured learning environment than that observed in Jean’s class. In one activity on cave painting, Jean grouped her students, assigned each member of the group a role, provided each group several natural materials (i.e., clay, berries, grass, lard) from which the students could make paint, and let the students work through the problem of making paint to create a design on brown paper. When Sue did the activity, she provided each child with some clay, then, as each child requested, she provided an amount of lard or oil to mix with it. The children then kneaded the clay and fat together to make paint sticks which were set aside overnight to be used the next day to paint paper.
In a follow-up interview 3 months later, Sue noted that, at the time of that activity, she was not yet comfortable with allowing her students greater control adding:

I think that next year, I’m going to try to have enough materials there and enough containers that they can do it themselves. After seeing what they did with it this year, it gives me a better idea of what I feel they can do on their own. For the first time out, not knowing what they can really do . . . so I didn’t want to take too much risk. . . . I was really surprised at what they could do and I felt like they could have done more had I realized it. [personal interview]

Clearly Sue was beginning to make changes in her teaching as an outcome of collaborating with Jean and continued discussion of what worked and what did not work. For her, every activity was an experiment in implementing a new way of teaching. Sue noted how important it was to be able to discuss with Jean, the outcomes of altering the way she taught science:

[After the lesson] We get back together and discuss and look at the results. . . . We really get excited because each one of us brings what our children did and we look at it and we talk about it and we decide what was the best experience for our children. We’re late a lot of afternoons leaving school because we get so involved in our own discussion. [personal interview]

As a result of their planning together, Sue and Jean were able to implement some problem-solving science activities in their classrooms. However, Sue’s long-held belief that noise and movement were problematic in school remained a constraint for her in giving her children the opportunity to have greater control in interacting with the materials and solving the problems. Thus, although these two teachers planned together and supported one another in the change process, the implementation of each planned activity was quite different for Sue than for Jean. These teachers were beginning to implement a curriculum that would allow their children to experience science as a way of knowing rather than a body of knowledge.

Collaboration was also an important factor in changing the way Becky and Gretchen implemented science instruction over the fall term. Becky noted that planning activities, gathering materials for them, and evaluating the activities with Gretchen was a key element in her ability to change what was happening in her classroom.

With the science, having somebody else there, especially for me because I would probably, I wouldn’t say I’d still teach the same [old] way, but I would probably have given up by now if it was just me trying to change against everything else. With all the pressures you have with everything else at school, if you’re one person it’s hard. But when you’re working together you’re able to share the load and get your ideas down and plan it and you know what you’re going to do. [personal interview]

Gretchen also credited her opportunity to plan with Becky as changing her attitude about teaching science as well. Furthermore, she identified what she learned about how children solve problems in science as carrying over into her mathematics teaching.

Processing, I think that came from science. I think the processing, walking through the process . . . Cause we walk through a process of thinking when we do our problems; what’s my problem?; how am I going to solve it?; what are my ideas on what I think will be the solution?; and finally solving the problem. [personal interview]

In each of these cases, teachers are supporting one another through the planning and implementation process by sharing ideas regarding what works and what needs to be changed.
Assertion 3: Saturday meetings provided a valuable opportunity to reflect on what worked and what did not. These experiences rejuvenated teachers and encouraged them to continue to use problem-centered activities. During the fall term, interactions among the teachers afforded by the Saturday meetings provided a support network for sustaining individuals as they attempted to change the manner in which they taught science. These Saturday meetings were particularly important to those teachers who did not have an in-school colleague to work with. Through the sharing of ideas, teachers assisted one another to work out ways to overcome perceived constraints.

For example, Helen worked at a school where there were no other participants. She had been teaching there for 8 years. Although Helen had no special interest in science, she enjoyed teaching science because the children “just love it. There hasn’t been one hands on activity that they have been bored with” (personal interview). However, her concerns that her third grade students would be required to take the science portion of the CTBS, that fourth grade teachers at her school expected children to take “out of the book tests,” and that she had to give a grade for science, had been a major influence on her decision to use the text as the center of her curriculum prior to the workshop.

With her decision to focus on integrating problem-solving in science with social studies, Helen found that other resources were much more useful to her than the text for providing children and herself with the information they needed to place various problems into a meaningful context. The Saturday workshops were one resource for ideas for problem-centered activities. She noted:

Each time I came I went back all fired up. Oh I’m gonna do that and do that, and I did. When the Saturday meetings stopped I really couldn’t say I did much problem-centered . . . I think you need someone to brainstorm with. [interview]

Elaine, like Helen did not have an in-school colleague. She described her science teaching as historically, teacher-centered with the children given few choices regarding what to do or how to do it. She enjoyed teaching science, but she was afraid to vary from prescribed activities because she felt uncertain about her own science content knowledge. The workshop helped Elaine to develop the confidence to risk providing children with more open-ended activities that they could explore in their own way. She stated, “One good thing I learned is, what if it doesn’t work out? That doesn’t matter.” Elaine came to view experiments that did not work as just another problem for herself and the children to solve. She described that the biggest difference in her teaching was that she had begun using problem-solving and open-ended questions throughout the curriculum. She noted:

No matter what the subject is, they find out or I ask them, “what do you think.” I’m trying to get my whole thinking more along those lines. . . . I try to be aware of it overall, without telling them things. I try to ask them questions. [personal interview]

Elaine credited what she learned at the Saturday workshops from other third grade teachers as helping her get past an early phase of nonaction. Although she noted that revising traditional science activities into problems is difficult, she is convinced that problem-centered learning is appropriate for third graders and she plans to continue to use it in her classroom.

Because the Saturday workshops allowed teachers from different schools to maintain contact with one another throughout the fall term, several of the teachers began to form working relationships with others outside their own school for sharing experiences and ideas. They began to share lessons and interpretations of what they were learning through telephone as well
as personal contacts inside and outside of school, thereby creating for each other a wealth of resources for teaching science. As Sue noted:

I’ve called and talked purposely, especially to one of the teachers [at another school] . . . She’s been doing this a little bit longer than I have and she’s been in third grade longer than I have so I would say, “I want to do this, but I don’t know how. Tell me how you do it.” And that’s really helpful because, and I may not do it exactly like she does, but it does give me a starting point.

[personal interview]

**Commitment and Change**

Although we have presented the more desired outcomes of the project, there were cases in which teachers did not participate after the summer workshop and problem-centered learning did not become a focus of their science curriculum. We noted a substantial dropout rate among those teachers who were recruited for the program after the original applicant file did not fill all the slots.

Among the seven teachers who dropped out of the project after the summer workshop, six had not been part of the original pool of applicants. Two teachers were assigned to teach in specialized areas, one in sixth grade social studies and the other a special writing project in which science was not part of the curriculum. Other reasons for leaving the program included the fact that several teachers, including one of the original applicants, perceived the science programs they had already established in their classrooms as having worked well with their students in the past. Two of these teachers were deeply involved in national science programs involving research using computer networking. Our classroom observations of these individuals suggested that, when they taught science, it was activity based, but they rarely implemented problem-solving activities. When we asked these teachers why they chose not to continue their participation in the project, they indicated that attending the workshop seemed a good way to earn in-service credit for certification and to get new ideas for science activities; however, they were focused on what they were already doing in science. Although disappointing, this outcome is not surprising. Teachers have multiple needs in their teaching and varying agendas motivated them to attend. These differences in motivation and apparent needs influenced how they interacted within the group and how what they learned through project activities was implemented.

Only one participant, Brenda, who had not originally been recruited, continued to participate. She joined the group with a colleague from her school, a second grade teacher with whom she worked during the summer and throughout the school year. Brenda had always enjoyed teaching science, but like Becky and Sue, was constrained by her own experiences in science to tend toward teacher-centered activities. Through her participation in the project and collaboration with her second grade colleague, she also began to change what happened in her classroom, moving toward more open ended problem-centered activities.

Clearly, providing opportunities for teachers to learn new ways of teaching science and for them to develop a collaborative support network for one another in the change process is not a sufficient condition to ensure that change will be implemented. This study suggests that change can be facilitated when there is a collaborative effort between teachers; however, a teacher’s individual commitment to change seems of equal importance to the creation of an environment that supports change. Those teachers who continued in the program had entered the program with a personal commitment to make problem-centered learning a part of their curriculum. Collaboration made it easier for them to act on their commitment.
CONCLUSIONS AND IMPLICATIONS

Because the selection of participants was based on their interest in teaching science and their openness to changing their classroom practices and providing leadership for others also to change, this study may be a biased representation of the potential for change through summer workshop activities. Change was highly likely because many participants expressed commitment to change from the outset. However, the long-term nature of this workshop also contributed to the success. Change involves individual’s examining their philosophical beliefs about the teaching and learning process and the impact of these beliefs on current practices (Westbrook & Rogers, 1996). The researchers and teachers agreed early on that change cannot occur in one-time, “show-and-tell” workshops.

We have learned from these teachers how collaborative relationships can be developed and how they facilitate teachers’ development of a sense of what problem-centered learning is and how to implement it. As teachers’ reconceptualized science teaching and learning with a focus on problem-centered activities, they identified three major areas of change in their views of teaching. First, they did not have to teach one subject at a time, but could integrate across the curriculum, sometimes interconnecting science concepts to a theme, rather than teaching an entire unit on one topic. Second, they found that interaction with their peers provided multiple opportunities for learning both content and pedagogy that would support their teaching. As these teachers began to implement problem-centered activities, rather than being constrained to use the textbook or cookbook laboratory activities to supply content, they became learners with their children. The extent of the science curriculum was broadened as teachers began to teach science in a manner previously avoided due to lack of knowledge. Finally, the teachers discovered that collaboration was not only essential, but very desirable to support the change process, to lessen the fear of risk taking, and to provide a forum for analysis of what works and what does not when change is implemented. They could concentrate on individual strengths and could use working relationships to combine resources to overcome difficulties. This study confirms prior research that characterizes the important role of collaboration in assisting teachers to reflect on whether what they tried in the classroom actually met their expectations and suggests that collaboration was an essential component in overcoming constraints to change such as time, lack of materials, or lack of ideas. Teachers felt that change was difficult; however, when they could discuss ideas, frustrations, and constraints, the end result was rewarding.

Numerous educational opportunities are provided for elementary teachers each year. The aspect missing in most of the activities is long-term collaborative contact with teachers both during the formal educational experience and then during the implementation periods that follow. Collaboration is not currently embedded within the cultures of most educational enterprises including the schools of our participating teachers. Thus, sustained collaboration is not easy. This is evidenced in our study by the fact that within-school collaborative relationships did not even form among teacher-participants unless they shared grade levels. Clearly, this type of program requires not only a significant time investment but common goals on the part of the teachers as curricula are developed and implemented.

It would be important to research why teachers drop out of this type of program. Fullan (1991) notes that for a given change in curriculum to be considered and tried it must fit the teacher’s priority. Innovations must also fit the needs of the teacher, be well defined, be well supported by others, and produce desired classroom results (Anderson & Pratt, 1995). What aspects were lacking in the program that influenced these teachers? Can leaving the program be attributed to lack of motivation or need, time limitations, lack of methodological fit, or some other unknown variable? Are individual or cultural factors the primary determiners of
continued participation? These questions are of particular interest because, in some schools, one teacher chose to remain in the program, while another dropped out.

Finally, research is needed to understand how this type of project will influence the participants’ interactions and curriculum over a period of a few years. The results of this study show that teachers working with other teachers can be a strong influence in improving science teaching in accordance with the standards set by the learned societies [suggested by the National Research Council (1996)]. However, this study involved only a small number of individuals within each school. If change is to extend beyond the individual classrooms of a few teachers, those teachers who have committed to change and found ways to support their own change through collaboration must take on leadership roles within their schools. Further research needs to examine how individuals who have learned how collaborative practice can improve their own science teaching may work with others to expand the collaborative culture.

REFERENCES


