

## Teacher Research Experiences, Partnerships With Scientists, and Teacher Networks Sustaining Factors From Professional Development

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*This study examined some long-term impacts of a professional development program, Teachers in the Woods. Several outcomes of the program were acknowledged by participants as having been valuable: a network of like-minded teachers, a network of scientists and teachers, and an increase in teachers' ecological knowledge and field skills. The authors made 3 observations with regard to professional development. First, engaging teachers in real-world field science research is an effective way for them to gain ecological knowledge and skills. Second, the collegiality among teachers and scientists developed during the period of field work can enhance science learning. Third, collegiality among teachers provides opportunities to discuss pedagogy-related issues. Both aspects of collegiality provide support mechanisms that sustain teachers' efforts to modify their teaching practices.*

### Introduction

The traditional approach to science education, where science is seen as a rigid body of facts, theories, and rules, does not adequately prepare students to address science issues in the context of engaged citizenship (Little, 1993; Millar & Osborne, 1998). In fact, this approach is responsible, in part, for driving students away from the field (Darling-Hammond, 1996). Without preparation in alternative strategies, teachers are more likely to rely on memorization and to manage their classrooms hierarchically, and they are less capable of managing instruction that is aimed at deepening students' levels of understanding. Alternative strategies discussed in this study include using inquiry-driven science and participation in real-world ecological research projects. Because they are vivid and visceral, direct experiences can be powerful and become a foundation upon which learners can attach their newly acquired knowledge schemes (Manzanal, Barriero, & Jiminez, 1999).

Teaching inquiry-driven science is a complex process, and there is a considerable gap between the mandate to teach science inquiry and the degree to which this is implemented in classroom settings (National Research Council, 1996). Crawford (2000), worked with a teacher who actively used the inquiry process to describe some of the abilities required for teaching science inquiry. These abilities included skill in creating meaningful, real-world research activities for the class, modeling

the behavior of professional scientists, and enabling students to collect and analyze real-world data. Crawford concluded that to increase the use of science inquiry in the classroom, professional teacher development must provide experience with these teaching practices.

Teachers in the Woods, the project described in this study, provided teachers with opportunities to directly participate in meaningful scientific research working side-by-side with scientists during a summer program. This process was intended to enhance teachers' skills and stimulate greater intellectual rigor, as recommended by Odom (2001). These experiences were also intended to broaden the concept teachers had of themselves as science teachers and provide the necessary confidence to lead students through similar science research projects.

Partnerships with scientists were a direct outgrowth of the summer research experiences. This was intended to strengthen teachers' knowledge and skills in conducting scientific research. As teachers worked in the field, many details about scientific methods and concepts were conferred to them by participating scientists. Kennedy (1998) found that improving and deepening teachers' knowledge and skills in science was a central outcome of professional development. She reported higher math achievement in schools where the teachers had participated in extensive training in math content. The depth of teacher change was correlated with the duration and intensity of the training.

It is expected that any significant change in teaching practice that results from a professional development program will occur over the long term. Teachers rarely change their practice completely or rapidly; instead, they tend to change over time, slowly picking up new material and incorporating it into their existing practice (Van Driel, Beijaard, & Verloop, 2001). Sufficient time, resources, and support are required to sustain change in classroom practices. According to Little (1993), the most promising forms of professional development communicate a view of teachers not only as classroom experts, but also as productive and responsible members of a broader professional community and as persons embarked on a career that may span 30 years or more.

Collegiality, the experience of a functioning professional community, is a critical factor in the professional development environment. Garet et al. (2001) found that opportunities for communication with peers were critical for effective professional development. Networks, coalitions, and partnerships provide opportunities for teachers to commit themselves to topics that are of intrinsic interest to them or that develop out of their professional work (Lieberman, 1995). School-based networks that include community agencies, teachers, and parents were found to help teachers be more effective while supplying the organizational needs required for implementing real-world student field projects (Driscoll, 2000). Effective communities typically allow for a degree of teacher autonomy and are linked to increased teacher commitment (Hausman & Goldring, 2001). Van den Berg (2001) described how both open individual (where one teacher is the sole representative from a school) and collective networks (where more than one teacher per school participates) help like-minded teachers share experiences and questions. Dresner and Starvel (2004)

described how partnerships with scientists helped teachers improve development of effective student projects.

Collegiality among peers seems to contribute to a sense of a common culture in which solutions to common problems are shared and risk taking is rewarded (Loucks-Horsley, Hewson et al. 1998). Networks of colleagues can sustain the individual's motivation to work for change over time, but a professional development program is also needed to instill an initial vision for change. In this program, teachers actively participated in the creation of scientific knowledge. The enthusiasm that was generated motivated participants to generate similar enthusiasm in their students through the use of similar projects. The details of how the Teachers in the Woods program was able to generate a vision for change and collegiality between both teachers and scientists and among teachers through direct participation in field research projects is described below.

### **Description of the Professional Development Program**

Teachers in the Woods (TIW) provided ecology research experiences for science educators at a variety of national forests and national parks. The program was delivered through a 5-week summer institute with additional academic-year workshops to ensure transfer of new skills to the classroom. During the summer institute, teachers received training in forest ecology and field techniques, while also working with scientists on one or more research projects at a site that was relatively close to their school. Teacher content knowledge was strengthened through training in the use of sets of ecological field research protocols.

Collegiality was fostered in several ways through this program. During a 1-week training, teachers participated in a variety of tasks intended to build group bonds. Next, teachers were teamed in self-identified groups to carry out a variety of research and monitoring tasks during a subsequent 4-week session. Throughout, the authors observed them informally discussing a wide variety of issues, both personal and teaching-related. Lastly, they were viewed and treated as colleagues by university and agency scientists.

Since teaching is viewed as contextual, participants in this program were not expected to follow a single model for implementing student projects. Instead, they were involved collectively and individually in the construction of models for bringing these skills into the classroom. Teachers were expected to experiment over a sustained period of time in creating and implementing their own student field projects in an authentic context. During the ensuing academic years, teachers conducted field-based projects with their students. Since 1997, a total of 260 science teachers have participated in this program.

Three significant results from the first several years of teacher participation in the program are reported in detail elsewhere (Dresner, 2002). To summarize, the program was found to improve teachers' capacity to provide field ecology experiences for their students. The program strengthened teachers' confidence in conducting field biology projects. Finally, the program contributed to a significant change in the way participants taught. The authors of this study have received unsolicited feedback

from numerous past program participants that described TIW as one of the most significant experiences in their professional careers. The authors were interested in finding out more details about the longer term impacts from this program and initiated a series of interviews with a set of previous participants.

### Methodology

The interviews for this study were conducted with teachers who had participated in TIW from 4 to 5 years ago. Out of the pool of 70 potential candidates that were recognized a priori, 25 had moved away or changed schools and could not be contacted, 12 indicated they were interested but were unable to participate due to time constraints, and 18 did not respond. A total of 15 were interviewed for this study. Since only 15 program participants were interviewed, the authors recognize that the results are not easily generalized to the larger group. The researchers had access to pretest data for all of the 70 teachers who were potential candidates. The pretests data contained information about the teachers' previous background knowledge and skills in research, how ecology and science inquiry had been integrated into their teaching, and the degree to which their students had participated in research and science inquiry prior to involvement in the TIW program. In addition, they had been asked if they considered themselves to be part of a professional network. The scores from the group of 15 who were interviewed were compared to the scores from the group of 70. Results of a Kruskal-Wallis test of difference in initial pretest scores between the group of 15 teachers who were interviewed and average scores of the whole group of 70 teachers showed no significant differences ( $p \leq .05$ ). These 15 teachers were at a comparable starting point with the other 55 potential candidate teachers.

Interview questions were standardized and developed from Patton (1990). The basic interview questions were as follows: What was your motivation for participating in TIW? What did your students receive from your participation? How have the skills you acquired impacted your teaching? How did participating in the summer field work effect your teaching? What were the results of your contact with scientists and teaching colleagues through this program?

Participants were sent the interview questions ahead of time to allow time for reflection. An external evaluator conducted all of the interviews in face-to-face meetings at the teacher's school site or, in two cases, over the phone. Each interview was transcribed. An enumerative rubric was designed by the researchers from the literature and from their own experiences with authentic science pedagogy (see Table 1) to test participant responses for the presence of each concept. The three main analytic units were

1. benefits of the program,
2. outcomes for teachers, and
3. outcomes for students.

**Table 1**  
*Analysis Rubric for Teacher Interviews*

Benefits of teachers in the woods	Outcomes for teachers	Outcomes for students
1. Participating in real-world science	1. Teaching science as opposed to teaching about science	1. Participation in real world science
2. Collective participation from teachers as a network of like-minded educators	2. Change in classroom environment	2. Enthusiasm for learning science
3. Increase in knowledge	3. Making contributions to the field of science	3. Gains in student achievement
4. Promoting active learning by becoming actively engaged in meaningful discussion, planning, and practice	4. Building a network of scientists and colleagues	4. Change in classroom facilitation
5. Fostering coherence by forming a wider set of opportunities for teacher learning and development	5. Making systematic change (e.g., increase in professional status)	5. Working on a team project
6. Having the experience of 5-week field work to draw upon in teaching	6. Motivation and excitement for teaching	6. Gaining ownership over project
		7. Participation within a community

After the text from all interviews were segmented into the three basic analysis units, a content analysis was run on the text using coding developed to classify each response. The coding consisted of a scale from 0–5, with 0 indicating *absence* and 5 indicating the *highest certainty of presence*. The content analysis was first pilot tested by a group of 15 research assistants to help them calibrate how they scored each unit. Interview responses were then examined for degree of presence or absence of each of the specific instances listed in any of the categories. Three different research assistants ran each content analysis three times for each interview, and only majority scores were accepted. Frequency counts and cross-tabulation analysis were run on these results to establish the rate of response for each category. Information from our database about teachers' previous experience in ecological sciences and years of teaching experience was obtained. Lastly, some participants were interviewed again during the following summer for more details concerning the nature of the collegiality that had been fostered. Ten out of the group of 15 were reached and available for face-to-face interviews. They were specifically asked to provide details on how collegiality was manifested and sustained after the professional development program.

**Table 2**  
*Frequency Analysis of Interview Data*

Responses	Percentage of cases (%)
Most beneficial aspect of participation was network of like-minded teachers	79
Most beneficial aspect of participation was network of scientists and teachers	79
Value of participation was significant gain in knowledge and skills in subject matter	77
Skills acquired during participation changed teaching style to focus on science as a process	67

## Results

The teachers who were interviewed represented the diversity of participants in the program. The teachers worked in schools located in communities with diverse socioeconomic and ethnic populations. They were all science teachers in grades ranging from the 6th to the 12th grade. Prior to participating in the program, five teachers had previous experience in field ecology ranging from a summer of data collecting in South America to 20 years of field experience in the National Park Service. Four teachers had 20 or more years of teaching and seven had more than 8 years of teaching.

Among the most frequent comments provided by teachers during the interviews concerned the beneficial aspect of networking among teachers and between scientists and teachers, gains in subject matter knowledge through participation, and acquisition of skills that led to changes in their teaching practices (see Table 2). Each of these topics will be treated in a separate section.

### Teacher Networks

Teachers described how their collegial relationships with other teachers were helpful in implementing their student projects (79%). For example,

*I have established beneficial, long-term relationships with other participants in the program . . . they've provided continued support on student projects. (middle school teacher)*

*Curriculum guides are not written for high school teachers who want to turn their kids on to science. The way the program proceeded, with other teachers giving their workable solutions, has really allowed me to find my own format for students to use in the field. (high school teacher)*

**Table 3**  
*Relative Frequency of Types of Teacher Networks Following Professional Development*

Examples	Relative frequency
Teachers stay in touch via e-mail and social meetings	highest
Teachers develop school-wide and districtwide informal collaborations to support student projects	high
Teachers send colleagues to TIW over subsequent summers to build core of common practice	moderate
Teachers develop long-term friendships with other teachers, fostering additional grassroots initiatives and positive change	less frequent
Teachers continue to work indefinitely with scientists	low

After the initial interviews, participants were contacted again for more details concerning the nature of the collegiality that had been fostered via their participation in the program. The most common form of contact was staying in touch via e-mail and social gatherings at each other's homes. Also common was the initiation of collaborations to support student projects. Seven of these teachers encouraged one or more of their teaching colleagues to attend the program so they could collaborate on large student projects with broad participation across classes. Some teachers credited the program with precipitating development of enduring friendships among teachers or among teachers and scientists. These results are summarized in Table 3.

### Scientist Partnerships

Teachers also described the value of collaborating with scientists at a high frequency (79%). The collegiality they established with scientists was important for them in sustaining their efforts towards reform:

*I had been very comfortable doing wildlife types of activities, but, through the summer research, I learned how to work with soils with the lead scientist. Now I do a soil lab, which I would have probably never done on my own. (high school teacher)*

*Through working with the scientist on my team, I learned more about mycorrhizae and began to lay ground work for my inquiry-based field project for my students. (high school teacher)*

The benefits of this collegiality included an improved sense of status they experienced as fellow scientists and the camaraderie established from having resolved particular problems in implementing the details of field work together:

*Working with Ian in the field was the most interesting project I did. He was exceptionally helpful, and we enjoyed collecting real data at his sites. (high school teacher)*

Lastly, the scientists were often helpful to the teacher over the school year:

*The contacts I had with professional scientists over the summer was the source of my success back in school. They have visited my class to talk about spotted owls, taken students out on field trips to study small mammals, loaned me equipment, and provided additional useful contacts. (high school teacher)*

### **Knowledge and Skills Acquired**

Seventy-seven percent indicated that the knowledge and skills acquired during participation continued to be of great value to them. For example,

*This has taken 2 years for me. Kids don't want to sit inside and answer questions from the book. Now I want them to design their own investigations. I've set my sights higher. I wouldn't have tried to do this before. (middle school teacher)*

A middle school teacher described how work in the field with students made it easier for him to teach concepts:

*I saw things happen in the field with the students, not from grading papers. I could reference real events, of what the students learned and how they learned it. It will make things easier for me and for the students. I can use real examples to explain broader environmental concepts. I use the project as a way to teach students to create their own ideas so they could ask questions, rather than regurgitate concepts. I have come to understand that scientific inquiry is not neat, it opens up the exciting world of the unknown. (middle school teacher)*

Sixty-seven percent indicated that the skills acquired during participation changed their teaching style to science as a process:

*I feel that this method works well because, even if the students do not discover the right thing, they get the experience of the process. I find this experience is difficult for students who are used to being led. They often ask, "Is this what we should be doing?" and I tell them I don't know, they should try it and see. The process is more interesting and fun. Some students perform much better in an environment where there is no right answer. (middle school teacher)*

*I learned science under the model that taught only content. Through the project, I have the idea to infuse inquiry in all my science instruction . . . I believe that successful teaching requires making inquiry as ways of thinking about science rather than an additional activity. Students don't have to come up with the right answer right away. (middle school teacher)*

During the interviews, teachers described how the program had changed their approach to teaching. One teacher began to work with other staff members as a team and developed a schoolwide, K–6, comprehensive outdoor science program. Another described how she had begun to see the scope of science teaching as broader and more integrated. Many teachers mentioned that they would not have been able to implement long-term student projects without having participated in the program. One middle school teacher described the effect of having started her own student field project: “I felt empowered because I successfully started my own field ecology project at our school site.”

## Discussion

During the 6 weeks that teachers spent in the Teachers in the Woods program, they acquired ecological knowledge and field experience by assuming the responsibilities of a field ecologist by working directly with practicing scientists and teaching colleagues. Over time, we expected to see a diminishing impact from the program. However, even after as much as 5 years, the respondents in this study indicated that they continued to apply what they had learned. The teachers started field ecology projects at their school sites, changed their classroom environments, and implemented long-term student science projects. These activities provide evidence that the respondents have undertaken field projects and have continued to modify their approaches towards teaching. Three distinct features of the program stood out to teachers over the long term as having had a lasting impact: partnerships with participating scientists, networks of teachers, and an emphasis on direct experience.

### Scientists Partnerships

Teachers need to know both the subject matter and how students can best learn the subject. Science teachers rarely receive training in both science content and process. This lack of training can hinder confidence and ability in implementing authentic science in the classroom. Little (1993) described the need for teachers to learn specific, transferable skills and practices with adequate opportunity to evaluate how to incorporate them. The benefits of working with professionals include opportunities for immersion in the open-ended process of understanding how natural ecosystems function. Teachers often pass these insights on to their students. For example, one teacher noted that “I have come to understand that scientific inquiry is not neat, it opens up the exciting world of the unknown.” Some teachers explained how they went on to transfer what they had learned to their students. For example,

“I learned science under the model that taught only content. . . . Now I infuse inquiry in all my science instruction.” As a result of their experience through the program, the teachers indicated that they had improved their teaching practices through using more real-world scientific research experiences.

### **Teacher Networks**

After building relationships with scientists and colleagues met through TIW, most of teachers in this study responded that this network of scientists and like-minded teachers was the most beneficial aspect of the program. Over the course of the summer program, participants and staff had helped to develop a culture that supported the philosophy and practices of teaching authentic ecological investigations. These ongoing relationships continued to foster the commitment of these teachers to use field projects in their teaching. Their collegiality provided confidence to use more innovative teaching techniques; practical opportunities to exchange workable ideas, solutions, and resources; and a sense of being part of a larger movement.

Some participants made initial contact with colleagues in their district during the summer program, and then either sustained that contact via e-mail or met up with these colleagues at a district meeting during the next academic year. One group of three participants described this reunion as fortuitous and began to meet on their own to discuss their initial work on student field projects. The group expanded to include other district science teachers who subsequently participated in the program. Eventually the initial group became close friends, camped together with their families, and developed cross-grade-level programs from elementary through high schools. They created a mandate for themselves to improve science instruction throughout the grades. Several members of this core group later took teacher union positions.

Many participating science teachers revealed that they experience themselves as operating as loners at their own school sites and have no support from other science teachers or from their administration. The opportunity to work with like-minded people from other schools and districts was described as “a relief” by one of these teachers. Others described the limitations of continuing to work in isolation while trying to introduce innovative ideas in their classes. When working outside of the traditional framework, and frequently outside of ones “comfort zone,” it was valuable to connect with someone else going through a similar transition. Van den Berg (2001) found in her study that sharing concrete experiences with the innovation allowed teachers to learn things from each other.

Teachers report to us that, despite the call for school-based professional communities (see, for example, Sykes, 1991), most schools are not providing opportunities for grassroots change through teacher-initiated networking. These sustained networks can be a powerful strategy to support educational reform movements from within.

### **Direct Experiences in Ecological Research**

Many teachers described themselves as having become so confident over the course of their summer experiences that they felt capable of leading their own students through a similar process. One teacher described how he had learned to correctly utilize the field equipment, sample the environment using transects, and collect accurate data during his summer research experience. Without this firsthand field experience, it is more likely that even veteran teachers would fall back upon teaching science as a body of facts.

Lieberman (1995) maintained that the teachers' learning and professional development should become more varied and engaging if those qualities are to be reflected in teaching practices. What we expect for science education (engaging students in experiencing and solving real problems, using their own experiences, working with others, etc.) should become part of the teachers' own experiences.

### **Collegiality and Direct Experiences**

To foster collegiality within the context of the professional development program, adequate time must be provided for participants to be able to grapple with new ideas and consult with colleagues and scientists. More broadly, this requires change in the professional development paradigm. Teachers should be doing real field work instead of just being talked at. They should be encouraged to help invent local solutions adapted to their own local specifications. Teachers need to be recognized as responsible and productive members of the broader professional education community (Little, 1993).

Through our experiences working with TIW, we have found that teachers need direct experience in field science research for themselves before being capable of providing one of sufficient quality for their students. Although numerous Web-based curricula and Web-based-only professional development opportunities are available to science teachers, these have limited success in changing teacher practice because they lack the opportunity for both direct experience and the development of collegiality. And although electronic networks can help facilitate networking among teachers who previously participated in face-to-face professional development, it is unlikely that Web-based networks alone can bring about the reforms needed in science education. At a minimum, Web-based programs can be infused with some degree of collegiality to enhance their impact. For example, Veal, Kubasko, and Fullagar (2002) found that by incorporating a buddy system into the teaching of a Web-based course, teachers received valuable feedback—and encouragement—that they might not have received otherwise.

### **Limitations**

All of the data used in this study is self-reported. The information reported may, therefore, be somewhat exaggerated or enhanced. For example, all of the respondents described improvements made in their teaching practices. Beyond the

anecdotal evidence supplied in each interview, we did not investigate the degree to which each particular school context might have supported the individual changes made by each teacher. We recognize that the institutional arrangements and interpersonal relationships at each participant's school site would have important impacts on their ability to implement education reform. In addition, all of the questions used in the interviews were intended to discover details about some of the positive impacts of the program. No questions were posed during the interviews that inquired about problems, oversights from the program, or barriers the teachers might have encountered when trying to start their projects at their schools.

To be able to generalize about all program participants, we had shown that the subgroup we interviewed was not unique from the entire group of potential candidates to begin with. However, this did not necessarily mean that this group did not have some unique qualities. We recognize that this subset of teachers may have progressed more quickly or may possess certain attributes that lead to their exemplary performance.

Although more than 240 teachers have participated in this program to date, it was only appropriate to interview those who had participated during the first 2 years. Since only 15 of these were interviewed, these results may not be easily generalized to the larger group. For example, 18 possible subjects for the study were unable to be contacted. This in itself could indicate a weak sense of collegiality. However, we believe that the trends described in this study merit the consideration of anyone who develops a substantial professional development program in the future.

### **Conclusions**

This study illustrates the long-term value of a professional development program that is designed to have a significant impact on the practices of teachers. Engaging teachers in real-world field science research is an effective way for teachers, and, consequently, their students, to learn ecological knowledge and skills. This experience can lead to science teaching for greater conceptual understanding and increased motivation on the part of the students. Adequate time must be allocated for science teachers to be immersed in the world of real science practice as a form of professional renewal. Because they had helped them produce authentic scientific knowledge, teachers also credited the partnerships with scientists as a contributing factor to their adoption of field projects as practice in their classrooms.

Collegiality is a desired outcome of professional development that must be fostered. Networks of teachers and of scientists and teachers may help maintain an initial commitment made by participants to include more innovative teaching techniques. When direct experience during professional development is supported by these informal networks, the effects may be greater than improving teachers' skills. It can lead to more widespread use of inquiry-driven science and real-world ecological research projects in schools.

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