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ABSTRACT

The ENVISION professional development model is designed to enhance teachers' understanding of environmental science concepts, inquiry, and inquiry teaching. In essence, teachers learn environmental science content, learn about scientific inquiry, and learn about how to teach science through inquiry. Further, participants are responsible for delivering professional development to their school-based colleagues about teaching environmental science through inquiry. Therefore, professional development is conducted at two levels. ENVISION staff train teachers participating in the institute (called Level I participants) and Level I participants train their school colleagues (called Level II participants). The study reported here was designed to evaluate the effectiveness of this professional development strategy. Results based on the first two years of the ENVISION program revealed that: Level I participants enhanced their understanding of inquiry and inquiry teaching, with 25 out of 30 (83%) changing their classroom practice; and that 21 out of 31 (68%) of Level II participants changed their classroom practice as a result of participating in Level I peer training. (Author)

The Effectiveness of the Envision Professional Development Model

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Abstract

The ENVISION professional development model is designed to enhance teachers' understanding of environmental science concepts, inquiry, and inquiry teaching. In essence, teachers learn environmental science content, learn about scientific inquiry, and learn about how to teach science through inquiry. Further, participants are responsible for delivering professional development to their school-based colleagues about teaching environmental science through inquiry. Therefore, professional development is conducted at two levels. ENVISION staff train teachers participating in the institute (called Level I participants) and Level I participants train their school colleagues (called Level II participants). The study reported here was designed to evaluate the effectiveness of this professional development strategy. Results based on the first two years of the ENVISION program revealed that: Level I participants enhanced their understanding of inquiry and inquiry teaching, with 25 out 30 (83%) changing their classroom practice; and that 21 out of 31 (68%) of Level II participants changed their classroom practice as a result of participating in Level I peer training.

The Effectiveness of the Envision Professional Development Model

Introduction

This paper reports on the ENVISION professional development model for middle level science teachers. The ENVISION program integrates learning environmental science content through inquiry with learning to teach science through inquiry. Pedagogically, this gives teachers an opportunity to immerse themselves in the essential features of classroom inquiry while learning scientific concepts related to the environment (NRC, 2000). In essence, teachers learn environmental science content, learn about scientific inquiry, and learn about how to teach science through inquiry. Further, participants are responsible for delivering professional development to their school-based colleagues about teaching environmental science through inquiry. Therefore, professional development is conducted at two levels. ENVISION staff train teachers participating in the institute (called Level I participants) and Level I participants train their school colleagues (called Level II participants). The research questions guiding this study were:

- Do Level I teachers change their classroom practice as a result of participating in the ENVISION program?
- Do Level II teachers change their classroom practice as a result of Level I peer training?

The significance of this research lies in its evaluation of a professional development strategy for enhancing science teachers' understanding of scientific inquiry and inquiry teaching; changing classroom practice. There is, however, little evidence of the effectiveness of teacher teams or teacher teams preparing other teachers or what Garet, Porter, Desimone, Birman, & Suk Yoon, (2001) called "collective participation." Determining the effectiveness of such a professional development strategy may provide evidence in support of utilizing peer trainers to implement effective professional development to enhance inquiry-based science teaching.

Theoretical Background

The ENVISION program is built upon constructivist (Piaget, 1970) and social constructivist (Vygotsky, 1986) principles of learning. Constructivist theory frames learning as an active, continuous process whereby learners take information from the environment and construct personal interpretations and meaning based on prior knowledge and experience (Driver & Bell, 1986; Roth, 1990). Although individuals construct understandings for themselves, personal meaning, meaning is not constructed in isolation from others (Bishop, 1985; Rogoff, 1990). Learning involves both a personal construction of meaning and a socially negotiated meaning (Cobb, 1990). For participating teachers this means that they construct or re-construct their understanding about science concepts and inquiry based on their experiences in "doing" science as a member of a scientific community. Social constructivism emphasizes learning by experiencing science--acting, thinking, seeing, and talking within the community or culture of science (Shepardson, 1999).

Background on Professional Development and Inquiry Teaching

I first present an overview of the literature on teacher professional development and how it contributed to the ENVISION professional development model. I then overview the literature on inquiry teaching and its incorporation into the ENVISION program.

Teacher Professional Development

The ENVISION program involves teachers in investigating the environment. Through this process, teachers experience instruction that promotes inquiry. Investigation of questions, investigations extended over time, learning science processes in the context of the investigation, using manipulative, cognitive and procedural skills, using evidence to support explanations, and communicating explanations to the community (NRC, 1996). Further, the process models the integration of inquiry into teaching and learning and the integration of science with teaching knowledge through collegial and collaborative learning. This addresses "the need for teachers to do inquiry to learn its meaning, its value, and how to use it to help students learn . . . [and] the importance of a community of teacher-learners that mirrors scientific communities " (NRC, 2000, p. 91). Loucks-Horsley, Hewson, Love, and Stiles (1998) summarized the emphases presented in the standards as changes:

> from transmission of knowledge to experiential learning; from reliance on existing research findings to examining one's own teaching practice; from individual-focused to collaborative learning; and from mimicking best practice to problem-focused learning (p. xv).

The ENVISION process enhances teachers' understanding through inquiry, providing teachers with opportunities to learn science and inquiry teaching, including:

1. How science subject matter and inquiry outcomes can be built into learning experiences.
2. How a deeper understanding of scientific concepts can promote discussion and the formulation of productive questions.
3. How essential features of classroom inquiry can be woven into learning experiences.
4. What it feels like to learn this way, complete with frustrations and struggles.
5. What roles and behaviors instructors can use that promote and support learning. (NRC, 2000, p. 101).

This shapes participating teachers' pedagogical content knowledge (Shulman, 1986) by integrating what they know about environmental science and inquiry with what they know about teaching science as inquiry. The ENVISION program emphasizes "doing" inquiry which informs teachers about their own classroom practice. Teachers take what they have learned and experienced about their environmental investigations and shape their classroom instruction to reflect their science experiences. Bybee (2000) provided three descriptions of inquiry for teachers to understand:

1) a description of methods and processes that scientists use,
2) a set of cognitive abilities that students might develop, and
3) a constellation of teaching strategies that can facilitate learning about scientific inquiry, developing the abilities of inquiry, and understanding scientific concepts and principles (p. 37).

Professional development programs that actively engage participants and model appropriate inquiry interact with teachers-as-learners rather than as information-gatherers. Research has shown that such professional development programs are effective in changing teachers' knowledge and practice (Brooks and Brooks, 1993; Bybee, 1993; Layman, Ochoa, and Heikkinen, 1996; Loucks-Horsley, et al., 1998; Sparks and Hirsh, 1997). Ballantyne and Packer (1996) state that while learning "how" to teach science, teachers should develop sound concepts and strategies that are appropriate for specific topics. Changing practice to reflect disciplinary inquiry requires that teachers develop a deeper understanding of the subject (Garet, et al., 2001) and of the investigative procedures of the discipline. Radford and Ramsey (1996) studied teachers who were trained in the process of science as well as in appropriate pedagogy. They claimed that this approach helped the teachers gain the knowledge, confidence, and skills to successfully teach their students. In a field monitoring program, Dresner (2002) reported that the professional development enhanced teachers understanding of scientific inquiry and changed their classroom practice; the teachers integrated field studies, environmental monitoring, into their teaching.

Garet, et al. (2001) in an analysis of teacher professional development found that: 1) time span and contact hours influenced teachers active learning in professional development experiences, 2) active learning enhanced teachers' knowledge and skills, 3) activities that emphasized content that were connected to reform efforts enhanced teachers' knowledge and skills, 4) enhanced knowledge and skills were likely to lead to change in teacher practice, and 5) the coherence of the professional development program (i.e., alignment with the teachers' classroom/school culture) influenced the likely hood that teachers changed their practice. Further, teachers communicating about practice and collective participation (e.g., teacher teams from the same school, grade, subject) influenced the degree teachers' changed their practice. Dimensions of active learning include: observed teaching, planning classroom implementation, reviewing student work, and being professional (e.g., presenting, leading, and writing) (Garet et al., 2001). Similarly to Garet et al. (2001), Loucks-Horsley et al. (1998) presented seven principles for effective professional development:

1. driven by a well-defined image of effective classroom learning and teaching
2. provide opportunities for teachers to build their knowledge and skills
3. use or model strategies teachers will use with students
4. build a learning community
5. support teachers to serve in leadership roles
6. provide links to other parts of the education system
7. are continuously assessing themselves and making improvements to ensure positive impact on teacher effectiveness, student learning, leadership, and the school community (p. 36-37).

The ENVISION program utilizes a professional development strategy whereby Level I participants design and conduct professional development for their school-based colleagues (Level II participants). This strategy of "Developing Professional Developers," formerly referred to as training-the-trainers, is an effective approach and is closely aligned with the standards (Loucks-Horsley et al., 1998). The "Developing Professional Developers" involves experiences that include:

> building the skills and knowledge needed to create learning experiences for other educators, including design of appropriate professional development strategies; presenting, demonstrating, and supporting teacher learning and change; and understanding in-depth the content and pedagogy required for effective teaching and learning of students and other educators (Loucks-Horsley et al., 1998, p. 44).

Inquiry and Inquiry Teaching

The standards for inquiry have been synthesized into five essential features: learners generating investigatible questions, planning and conducting investigations, gathering and analyzing data, explaining their findings, and sharing and justifying their findings with others

(NRC, 2000). Inquiry, as presented in the NRC standards, moves learners beyond merely hands-on experiences to experiences that engage learners in discovering phenomena, exploring interesting possibilities, and making sense of scientific ideas. Luft (1999) claimed that teacher understanding of the elements of inquiry increased the components of inquiry in classroom teaching. Rakow (1998) suggested five teacher behaviors and attitudes that contributed to successful inquiry teaching:

1. Model scientific attitudes
2. Use creativity to adapt existing materials to an inquiry style
3. Be flexible in solving problems – use alternative strategies
4. incorporate effective questioning strategies
5. focus on thinking skills – science process skills as well as facts (p. 16-18)

Inquiry teaching can occur at several levels, from highly structured activities to open-ended lessons (Tafoya, Sunal, & Knecht, 1980) based on the teachers' goals:

1. more teacher-directed with guiding questions provided and step-by-step procedures given, students are involved with the materials in an effort to re-discover some identified concept (a confirmation activity)
2. less teacher-directed whereby students are given a guiding question and the procedures to investigate (structured inquiry)
3. more student-centered with the teacher providing the guiding question and suggesting materials and the students design and direct the investigation (guided inquiry)
4. student-centered allowing students to generate questions based on observations and interest, materials are provided as needed, and the teacher serves as facilitator of the activity (open-inquiry).

The ENVISION professional development model engages teachers in three basic types of inquiry activities: field studies/environmental monitoring, investigative laboratories and models, and environmental science research. These activities emphasize inquiry teaching along a student-centered continuum (NRC, 2000), from more student-centered to less student-centered (Figure 1). In environmental research, teachers generate research questions based on site surveys and observations, plan investigations using scientific equipment and tools, analyze data using scientific ideas, and communicate findings and processes through the creation of authentic products. In field studies and investigative laboratories teachers engage in scientifically oriented questions and give priority to evidence, but the procedures and equipment used is less student centered. In both activities, teachers formulate their own explanations based on data and guidance from identified resources.

Figure 1. ENVISION Inquiry Activities and the NRC Essential Features of Inquiry

NRC Essential Features	**Variations** More learner directed.............................More teacher directed			
Learner engages in scientifically oriented questions	ER	IL FS		
Learner gives priority to evidence	ER IL FS			
Learner formulates explanations	ER IL FS			
Learner connects explanations to scientific knowledge		ER IL FS		
Learner communicates and justifies explanations		ER IL FS		

ER = Environmental Research, FS = Field Studies, IL = Investigative Laboratories

Methods

Methodological Perspective

A study that looks at the experiences of teachers in their real-world context calls for an approach based in the constructivist/interpretivist perspective. According to Schwandt (1994) the constructivist/interpretivist believes that to understand the world one must interpret it. To interpret the world one constructs meanings; in this study, the researcher constructed meanings of the constructions that the teachers construct. The nature of an interpretivist perspective recognizes that the researcher plays an integral role in the construction of meaning. The interactions between the researcher and the participants provide opportunities for the clarification and reinterpretation of these constructs, from the researcher's perspective and the participants' perspective. Since the researcher and the participants enter the study with preexisting knowledge and this knowledge affects the interpretations that occur, an element of subjectivity exists. Recognizing the elements of subjectivity and by focusing on the data, the influence these elements have on the interpretations and constructions that emerge are minimized.

Participants

Participants for this study were teacher teams enrolled in the ENVISION program. Teams consisted of Level I and Level II participants. Level I teachers participated in the summer institute and designed and conducted professional development for teacher colleagues—Level II participants. Thus, Level I teachers were trained by ENVISION staff and Level II teachers were trained by their school colleagues. There were 8 teams year one (Cohort I) and 10 teams year two (Cohort II). The number of teacher participants was: 16 Level I and 14 Level II year one and 14 Level I and 17 Level II year two.

The gender distribution between Level I and Level II participants was similar: 57% of Level I teachers were female and 43% males; whereas 58% of Level II teachers were female and 42% male. The participants were predominately white (88% Level I and 100% Level II). The number of students per-teacher varied between cohorts but was similar between Levels: Cohort I participants reported an average student load of 119 students for Level I and 105 for Level II; Cohort II participants reported an average student load of 77 for Level I and 79 for Level II. The majority (50%) of participants came from rural or small town school settings compared to urban/inner city settings (37%).

Additional demographic data for Cohorts I and II indicated that: 1) Level I participants have less years of teaching experience, with an average of 10 years versus 14 years for Level II teachers; 2) Level I teachers tended to participant more often in staff-development programs, with 33% of Level I teachers having participated in a staff-development program in the past year compared to 25% of Level II teachers; and 3) 40% of Level I teachers have a graduate degree compared to 52% of Level II teachers.

Data Sources and Analysis

The primary data sources for this study included:

- Observations of classroom practice and Level II training
- Interviews about classroom practice, inquiry teaching, and Level II training
- Pre and post lesson profiles of classroom practice
- Open-response survey about inquiry teaching
- Instructional and Level II training plans and reports (documents)

Analysis of these data sources involved both an inductive and deductive approach. The lesson profiles, classroom observations, open-response survey, and instructional and Level II training plans were analyzed from a deductive perspective. The deductive aspect occurred in the use of a specified set of criteria or codes. The interviews and observations of Level II training were analyzed inductively. These data sources were analyzed through inductive analysis in order to identify important themes and patterns. In accordance with Patton (1990), this inductive analysis resulted in the identification of concepts by the researcher that were not expressed by the participants (sensitizing concepts) as well as concepts expressed by the participants (indigenous concepts).

Classroom Observations and Lesson Profiles. Classroom observations and lesson profiles were analyzed using the Inquiry Analysis Tool (IAT) (Bell, 2002). This analysis tool combined the essential features of classroom inquiry as outlined in the NRC 2000 standards with the Extended Inquiry Observational Rubric (EIOR) (Luft, 1999). The EIOR was chosen as the basis for the IAT because it had been developed and tested by experts and teachers, and it "represent[ed] sound science instruction and scientific inquiry as discussed in the National Science Education Standards" (Luft, 1999, p. 12).

The IAT consists of 11 dimensions of inquiry that are scaled from 0 to 5, less student-centered to more student-centered. Participants were observed teaching during the academic year; lesson profiles were submitted prior to attending the summer institute and at the completion of the program. The lesson profiles were analyzed statistically to determine if any significant difference existed in the 11 dimensions over time. Each lesson profile dimension score was collapsed into one of two categories: scores between 0 and 2 were categorized as less student-centered and scores between 3 and 5 were categorized as more student-centered. A 2x2 matrix (less/more student centered x pre/post lesson profile) based on frequency for each dimension was tested for significance using the Chi-square test.

Open-Response Survey and Interviews. The open-response survey and interviews were analyzed based on the NRC (2000) essential elements of inquiry. Teacher responses were coded based on the five essential elements of inquiry. These codes were operationally defined based on the NRC (2000). Responses were coded as reflecting the following:

- Scientifically oriented questions
- Priority given to evidence
- Form explanations
- Evaluate explanations
- Communicate and justify explanations

Thus, a teacher's written and oral responses may reflect one or more of the above codes. Frequencies of responses were determined for each code for the pre-institute and post-institute surveys and interviews. The open-response survey was completed prior to attending the summer institute and at the completion of the program. Teacher interviews were conducted during the academic year. The open-response survey was analyzed statistically to determine if any significant difference existed in each of the five elements of inquiry over time. Each response was grouped into one of two categories: the response reflected the inquiry element or the response did not reflect the inquiry element. A 2x2 matrix (reflect/doesn't reflect x pre/post institute) based on frequency for each inquiry element was tested for significance using the Chi-square test.

Level II Training Plans, Observations, and Interviews. The Level II training plans and the observations of and interviews about Level II training were coded into one of four categories or modes of delivery and activity. These categories of Level II training emerged from the analysis of the data sources:

- Category III, modeling and practicing of techniques and activities
- Category II, lecturing and demonstrating of techniques and activities, limited practice
- Category I, discussing informally/formally about techniques and activities, no practice
- Category 0, no training

Results

I first present the results for Level I participants that documents change in practice followed by the results that illustrate the impact of Level I peer training on Level II classroom practice.

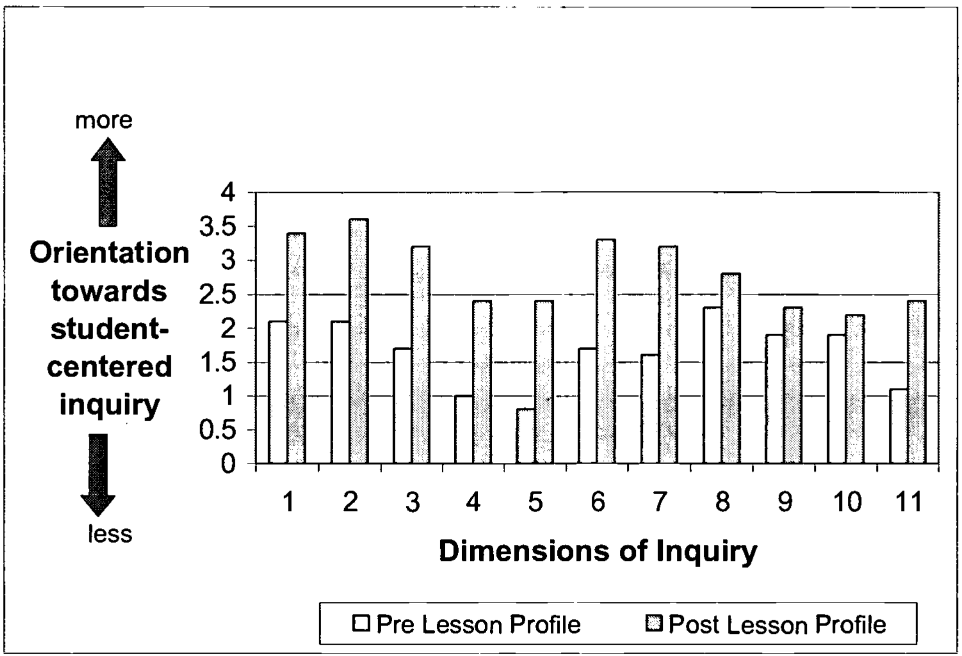
Change in Level I Participants

The analysis of teachers' pre and post project lesson profiles indicated an overall shift in inquiry level toward a student-centered orientation. Major changes were observed in the categories of "teacher as guide," "assessment," "cooperative learning," "scientifically oriented questions," "designing and conducting investigations," "evidence as a priority," and "analyzing data" (Table 1, Figure 2). On the other hand, the post lesson profiles showed little change in the categories of "justifying explanations," "formulating explanations," and "communication" (Table 1, Figure 2).

Table 1. Mean Pre and Post Institute Lesson Profile Ratings for Level I Teachers.

Dimension of Inquiry	Mean Rating Pre-Institute	Mean Rating Post-Institute
1. Teacher as a Guide	2.1	3.4
2. Assessment	2.1	3.6
3. Cooperative learning	1.7	3.2
4. Scientifically oriented questions	1	2.4
5. Designing and conducting investigations	0.8	2.4
6. Evidence as a priority	1.7	3.3
7. Analyzing data	1.6	3.2
8. Formulating explanations	2.3	2.8
9. Justifying explanations	1.9	2.3
10. Communication	1.9	2.2
11. Mathematics	1.1	2.4

Figure 2. Mean Pre and Post Institute Lesson Profile Ratings for Level I Teachers.



KEY to Dimension of Inquiry:

1 Teacher as guide
2 Assessment
3 Cooperative learning
4 Scientifically oriented questions
5 Designing and conducting investigations
6 Evidence as a priority
7 Analyzing data
8 Formulating explanations
9 Justifying explanations
10 Communication
11 Mathematics

The Chi-square analysis showed a major difference between the pre-institute and post-institute lesson profiles for 5 of the 11 dimensions: Teacher as a Guide, Assessment, Cooperative Learning, Scientifically Oriented Questions, and Designing and Conducting Investigations

(Table 2). Based on the Chi-square analysis there was an improvement in 2 of the dimensions (e.g., Evidence as a priority and Analyzing data) and little improvement in 4 of the dimensions (e.g., Formulating explanations, Justifying explanations, Communication, and Mathematics) (Table 2). Although the Chi-square analysis (Table 2) supports the observed difference in the mean lesson profile ratings (Table 1, Figure 1), it reveals that the change in the mean ratings for the Evidence as Priority and Analyzing Data dimensions is the result of several participants scoring relatively high on those dimensions compared to other participants.

Table 2. Chi-square and Probability Values for the Lesson Profiles

Dimension of Inquiry	Chi-square value	Probability value
1. Teacher as a Guide	10.16	.001
2. Assessment	11.81	.001
3. Cooperative learning	13.35	.001
4. Scientifically oriented questions	9.06	.003
5. Designing and conducting investigations	6.47	.011
6. Evidence as a priority	3.17	.075
7. Analyzing data	2.81	.093
8. Formulating explanations	0.08	.782
9. Justifying explanations	0.65	.422
10. Communication	1.08	.299
11. Mathematics	0.71	.400

The results from the open-response survey indicated that teachers' understanding of the essential features of inquiry and its integration into teaching were enhanced (Table 3). The percentage of teachers identifying scientifically oriented questions, priority given to evidence, and communicating and justifying explanations as components to inquiry teaching substantial increased from pre to post institute. The increase in these elements from pre-institute to post-institute was statistically significant (Table 3). Although having students evaluate explanations showed an increase, it was not statistically significant; only a small percentage of teachers stressed the importance of having students evaluate explanations (Table 3). The percentage of teacher responses stating that they would have students form explanations increased from pre to post institute, however, the increase was not statistically significant (Table 3).

Based on the analysis of the classroom observations and teacher interviews, and supported by the survey results, 25 out of 30 (83%) of Level I teachers demonstrated a change in their classroom practice (Table 4). By change I mean that these teachers integrated student generated research, field studies and investigative laboratories into their classroom for the first time. As a side note, 16 Level I teachers also integrated ENVISION modeled web-based activities into their classroom instruction (e.g., TerraServer, Enviromapper, Surf-Your-Watershed).

Table 3. Cohort I and II Open Response Survey Results: Essential Features of Inquiry.

NRC Essential Features Of Inquiry	**Percentage Indicating Feature**		**Chi-Square and Probability Values**	**Response Examples**
	Pre	**Post**		
Scientifically oriented questions	50%	83%	$X^2= 7.50$ $p= .006$	Students develop their own investigatible question, students picked from a variety of questions, students were given questions.
Priority given to evidence	60%	83%	$X^2= 4.02$ $p= .045$	Students designed and conducted investigations, collected samples, analyzed different parameters, and did different types of testing.
Form explanations	40%	42%	$X^2= 0.07$ $p= .793$	Students used data and graphs to explain results, discuss why results differ among groups, discuss why certain results were found, and propose recommendations or solutions to problems.
Evaluate explanations	20%	33%	$X^2= 1.36$ $p= .243$	Students compare results to previous findings, they continuously monitored certain data, and compared results to science content.
Communicate and justify explanations	70%	92%	$X^2= 5.45$ $p= .019$	Students shared results through class/group presentations, posters, PowerPoint, diagrams, writing letters, reports, and articles, working with younger students, graphs, and maps.

Table 4. Change in Level I Practice, Cohorts I and II.

Change in Instruction	**Level I Teachers**		
	Cohort I n=16	Cohort II n=14	Totals n=30
Student generated research projects	1	4	5
Field studies/surveys and environmental monitoring	9	7	16
Investigative laboratories, questions before answers (e.g., soils, drinking water)	4	7	11
Models, questions before answers (e.g., wastewater, landfills, groundwater)	2	2	4
Web-based (e.g., TerraServer, Enviromapper)	7	9	16
No change in practice	2	3	5

Note: Totals equal more than sample size because some individuals changed in multiple ways

The Impact of Level I Training on Level II Teachers

Although all Level I teacher-teams designed professional development plans for their Level II teammates that reflected modeling and practicing (Category III); only 39% of the teams implemented such a professional development approach (Table 5). Several teams (28%) did not implement any professional development, resulting in no change in practice for seven (23%) of the Level II teachers (Table 6). Category II and Category I training was successful at changing the practice of six out of nine (67%) Level II participants, whereas Category III training changed the practice of all 15 (100%) Level II participants (Table 6). Thus, 68% (21/31) of the Level II participants changed their classroom practice, in some way, as a result of peer training. The only category of professional development that resulted in Level II teachers integrating student generated research into their teaching was modeling and practicing (Table 6). It also turns out that the Level I teachers of these teacher-teams integrated student generated research into their teaching.

Table 5. Categories of Level II Training: Cohorts I and II.

Category of Level II Training	Number of Teams		
	Cohort I (n=8)	Cohort II (n=10)	Total (n=18)
Category III Modeling and practicing of techniques and activities	2	5	7
Category II Lecturing/demonstrating of techniques and activities, limited practice	2	1	3
Category I Discussing informally/formally about techniques and activities, no practice	2	1	3
Category 0 No training	2	3	5

Table 6. Relationship between Category of Level II Training and Change in Level II Practice.

Category of Level II Training (n = Level II teachers)	Change in Level II Instruction	(n=14)	(n=17)	Change in Practice: Number of Teachers
Category III Modeling and practicing (Cohort I, n=4; Cohort II, n=11)	Student research	2	10	15/15
	Field studies	4	11	
	Investigative laboratories	2	11	
	Models	2	0	
	Web-based	3	9	
Category II Lecturing/demonstrating, limited practice (Cohort I, n=3: Cohort II, n=2)	Field studies	2	1	6/9
	Investigative laboratories	1	1	
	Models	1	1	
	Web-based	2	1	
Category I Discussing informally/formally, no practice (Cohort I, n=3; Cohort II, n=1)	Field studies	1	0	
	Investigative laboratories	0	0	
	Models	1	1	
	Web-based	0	1	
Category 0 No training (Cohort I, n=4; Cohort II, n=3)	No change in practice	4	3	0/7

Note: Totals equal more than sample size because individuals changed in multiple ways

Discussion

The ENVISION professional development program promoted inquiry learning by interact with teachers-as-learners rather than as information-gatherers. This experience actively engaged teachers and modeled the type of teaching intended for the classroom. The findings demonstrate that such professional development programs that involve teachers as learners do in fact result in teachers' construction of meaningful knowledge about inquiry and skills for inquiry teaching

(Brooks and Brooks, 1993; Loucks-Horsley et al., 1998; Sparks and Hirsh, 1997). Thus, professional development programs should model the same types of learning activities that they wish to have teachers incorporate into their classrooms.

Similarly, Ballantyne and Packer (1996) stated that if environmental science education experiences are to be effective, "teaching strategies must be considered as interdependent with conceptual content rather than as general strategies that are universally applicable" (p. 26). In other words, while learning "how" to teach environmental science, teachers should develop sound environmental concepts and strategies that are appropriate for specific topics. Teachers who participated in ENVISION experienced inquiry-based learning opportunities called for in the standards while learning environmental science concepts. This resulted in teachers utilizing these pedagogical strategies in their classroom, changing their practice. The findings of this study are similar to Dresner's (2002), who found that professional development that prepared teachers to conduct forest biodiversity monitoring resulted in teachers integrating such monitoring projects into their curriculum.

The ENVISION professional development model successfully changed teachers practice by shifting their pedagogy toward a more student-centered inquiry orientation (e.g., student generated research questions, field studies, investigative laboratories). Therefore, it appears that modeling and engaging teachers in environmental research, field studies, and investigative laboratories does promote and support change in teacher pedagogy. Not all teachers, however, integrated student generated environmental science research into their classroom. Thus, engaging teachers in authentic environmental science research may have enhanced their knowledge and understanding of inquiry, it did not translate into a change in classroom practice.

Like Luft (1999), I found that an increase in teachers' understanding of inquiry was necessary in order to change their inquiry-based teaching; however, an increase in understanding of inquiry was not the only factor that influenced teachers to change their practice. Based on the interviews, factors that influenced teachers' integration of environmental science research in to their classrooms were: time management issues, curricular coverage concerns, perceived instructional support and structure (control) problems, and transportation and equipment expenses. These in part reflect alignment issues (Garet et al., 2002), but also teacher confidence issues. Although these teachers developed the understandings identified by Bybee (2000), factors external to inquiry teaching, perceived or real, limited the scope that teachers changed their practice. Similar to Garet et al. (2002), active learning experiences enhanced teachers' understanding of inquiry and inquiry-based teaching; however, it did not lead to change in the practice of all teachers.

The increase in the number of teams implementing Level II training at the modeling and practicing level (Category III) from year 1 to year 2 is likely the result of the summer institute providing additional peer training experiences for Cohort II participants, that is better preparing Cohort II, Level I participants to conduct professional development. Based on teacher interviews and survey responses, teams that did not implement peer training did not because of personality conflicts, lack of commitment on behalf of the Level I and II team members, spatial arrangement of participants (different school buildings) and change in teaching assignment. So, well collective participation (Garet et al., 2002) is important to changing teacher practice it does not ensure success. Additionally, time and school district support influenced the degree of success of peer training. Teams that were committed to changing classroom practice found the time and engaged in the modeling and practicing of techniques. These teams conducted their professional development over time on weekends and after school. All Level II professional development that reflected modeling and practicing involved teams that were either from the same building, same grade, or same discipline across grades in the same building (Garet et al., 2002), or were from grade-level teaching teams.

In conclusion, engaging teachers in learning environmental science through inquiry positively impacted teachers' understanding of inquiry and inquiry teaching, resulting in teachers changing their classroom practice. Further, teachers conducting professional development that engaged school colleagues in inquiry resulted in a change in the practice of school colleagues. It is essential that professional development provide teachers of science with the opportunities to learn science and to learn about inquiry through doing inquiry—acting, talking, seeing, and thinking in a community of learners.

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