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ABSTRACT

This paper explores the effectiveness of teacher-scientist collaborations in bringing inquiry into pre-college classrooms. The Montana Organization for Research in Energy (MORE) and the University of Montana sponsored two institutes on "Teaching about Energy through Inquiry" for middle and high school teachers and energy scientists in 1996 and 1997. The primary goals of the institutes were to: (1) facilitate partnerships between teachers and scientists; and (2) increase the use of inquiry as a teaching method in energy education. This paper briefly characterizes these institutes and describes the assessment efforts used to evaluate the effectiveness of the institutes. Closing comments on the institutes' efforts in effectively facilitating collaborations between teacher and scientists are provided. Contains 20 references. (CCM)

FACILITATING TEACHER-SCIENTIST COLLABORATIONS: TEACHING ABOUT ENERGY THROUGH INQUIRY

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Introduction

The National reform movement to change the way science is taught calls for a shift in the educational focus to include the student in the process (National Commission on Excellence in Education 1983, American Association for the Advancement of Science 1990, National Research Council 1996). Science curricula that use student-centered, inquiry methods have been shown to be highly effective in improving content learning, science process and creativity, logic, language skills, and attitudes toward science and science learning (Renner 1973, Bredderman 1982, Ebert-May et al. 1997). These methods have been especially effective for students usually characterized as "slow learners" (Carpenter 1963), "disadvantaged" (Bredderman 1982), and groups currently underrepresented in scientific professions.

Unfortunately, teachers uncomfortable with science may be reluctant to use inquiry-based methods that stress the process of science, rather than only the end products of scientific investigations (Mechling and Oliver 1983, Alper 1994). Many teachers, especially in elementary and middle school settings, feel they have inadequate training to teach science, and that they lack access to teaching materials and the most recent scientific information (Greene 1991). Numerous studies report that science teachers want training programs that are activity-oriented, and which give them access to local materials and human resources (Mechling and Oliver 1983, Greene 1991, Yager 1991, Hays 1994). Assessment of teacher training programs which stress hands-on science learning focused on process and application have indicated improved teachers' attitudes about science and increased their comfort levels with teaching science (Sandman 1988, Feazel and Aram 1990, Greene 1991, Brewer and Manning 1995, Caton et al. 1997).

One effective strategy for demystifying science for teachers who are uncomfortable with this subject may be collaboration between teachers and scientists (Alper 1991). Increased interest in and understanding of scientific processes leads to greater confidence in their ability to teach using inquiry (Brewer and Manning 1995, Caton et al. 1997). Many research scientists affiliated with universities or colleges have teaching requirements, and have an interest in science education at the precollege level as well. However, researchers tend to have little or no formal training in teaching, and often have inadequate knowledge of methods appropriate for teaching younger students. Participation in precollege science education programs can teach valuable lessons to researchers about education, as they work with experts in the education field. But successful teacher-scientist partnerships can be difficult to achieve, and little is known about the effects of such collaborations on participants and their students.

To explore the effectiveness of teacher-scientist collaborations to bring inquiry into precollege classrooms, the Montana Organization for Research in Energy (MORE) and The University of Montana sponsored two institutes on *Teaching About Energy Through Inquiry* for middle and high school teachers and energy scientists in 1996 and 1997. The primary goals of the institutes were 1)to facilitate partnerships between teachers and scientists, and 2)to increase the use of inquiry teaching in energy education. This was accomplished through two- and three-day institutes where teachers and scientists worked together in small groups where they participated in energy-focused inquiry activities and collaborated on energy investigations for future classroom use.

This paper will briefly characterize the institutes created to help facilitate partnerships between teachers and scientists and increase inquiry teaching. This will be followed by the assessment efforts used to evaluate the effectiveness of the institutes. Concluding the paper will be closing comments regarding the institute efforts in effectively facilitating collaborations between teacher and scientists.

Characterization of the Institutes

In the development of the *Teaching About Energy Through Inquiry* institutes the two goals of facilitating partnerships between teachers and scientists, and increasing the use of inquiry teaching in energy education were identified. To accomplish these goals it was established that the institutes would: stress equal status for teachers and research scientists, encourage two-way exchange of expertise, have participants work in small groups which involved engaging inquiry-focused projects, and use low-tech commonly available materials. Each institute was either two- and three-days in length with the focus of each day involving energy-focused inquiry activities. Teachers and scientists worked together in small groups as they tested and critiqued inquiry-based investigations developed by institute leaders. Investigations varied from an open-ended inquiry approach to more of a guided approach. As collaborators, they discussed the use of inquiry learning strategies in both precollege and college classrooms as well as the value and challenges of collaborations between teachers and scientists. To complete the institute teachers and scientists worked in teams toward the development and eventual implementation of energy investigations to be used in teachers classrooms.

Assessment

Both qualitative and quantitative assessments were used to assess institute impacts (Fraser et al. 1990). To assess how the institute facilitate partnerships between teachers and scientists the following methods were used: pre- and post-institute surveys of teacher and scientist participants were completed, descriptive observations were recorded throughout the institutes, and interviews were completed with participating teachers and scientists. To assess whether there was a change in the use of inquiry teaching practices the teacher classroom was the focus of assessment. Assessment of the classroom learning environment involved two variables: the degree of inquiry teaching used in the classroom and how students collaborated in groups during inquiry investigations. Data collected involving these variables included: classroom observations, teacher and students questionnaires, and lesson plans developed by teachers. Below is a description of each assessment measure used.

Facilitate Partnerships Between Teachers and Scientists

Participant Surveys. Before and after the institute, participants completed surveys which included both qualitative and quantitative questions related to science education and collaboration. Pre-institute teacher surveys involved questions about workshop goals, attitudes toward science, and perceived obstacles to integrating energy investigations into the classroom. Pre-institute scientist surveys involved questions about scientists experience and interest in working with teachers, workshop goals, familiarity with teaching methods, and obstacles to integrating work in their field into precollege classrooms. Teachers and scientists were asked to rate (using a Likert scale of 1 to 5) the importance various topics related to the workshop.

Post-institute surveys were identical for teachers and scientists. Participants rated the value of institute discussions, investigations and interactions, and resources. Open-ended questions probed for details on positive and negative aspects of the institute, changes in skills and attitudes about teaching through inquiry, effectiveness of collaborations and interest in continued collaboration, investigations, and obstacles to integrating inquiry.

Institute Observations. During the two- and three-day institutes observations were made of two variables: group dynamics and collaboration among participants. Each variable was treated as descriptive in nature and recorded using a continuos narrative recording approach. Observations were recorded throughout the length of the workshop.

Participant Interviews. Participants from the May 1996 workshop were interviewed the following December. Interview questions pertained to the extent of post-institute collaboration between teachers and scientists, and use of inquiry-based lessons in classrooms during the first half of the current school year (see Table 1).

Inquiry Teaching in Energy Education

Classroom Observations. To measure the degree of inquiry used in the classroom the IQ questionnaire was used (Lawson et al. 1976). This questionnaire asks observers to answer twenty five questions regarding four variables which include the lesson, student behavior, teacher behavior, and questioning techniques. In this assessment two observers completed the IQ questionnaire after observing a completed classroom activity before and after the workshop occurred. Prior to making classroom observations observers adjusted their observations between each other by completing the IQ questionnaire at two classrooms not included in the assessment.

Student Collaborations: To measure how students collaborated in groups during inquiry investigations the learning environments questionnaire "My Class Inventory" (MCI) was used for the Middle School classrooms and the Science Laboratory Environment Inventory" (SLEI) was used in the High School classroom. The MCI questionnaire measured five elements of the classroom environment: student satisfaction with the class, class cohesiveness, friction among classmates, difficulty of work, and classmate competitiveness (Fisher and Fraser, 1981). The SLEI questionnaire measured five elements of the classroom environment including student cohesiveness, open-endedness of activities, degree of integration with classes, rule clarity, and the material environment (Fraser et al. 1995). These questionnaires were given to students who were enrolled in participating middle and high school teachers classrooms before and after the institute.

Lesson plans. Participating teachers submitted lesson plans for implementing inquiry-based units in their classrooms based on what they had learned in the institutes. Lesson plans described the classroom lessons they had planned, the nature of anticipated collaborations with scientists and teachers, and their resource needs.

Results

In 1996, four teachers and eight scientists participated in the pilot institute. In 1997 twenty-five teachers and six scientists attended the institute. Below are the results of the data collected for each goal stated for the institute. Concluding each result section is a summary and critic of whether the each goal of the institute was met.

Goal 1: Facilitate Partnerships Between Teachers and Scientists

Pre-institute Surveys. Teacher responses involved 29 returned pre-institute surveys (Table 2). The primary goals teachers stated for attending the institute were to 1)learn new, hands-on ways to teach science, 2)learn more about inquiry instructional strategies, and 3)increase their content knowledge. Before the institute, teachers were excited by the experimentation and discovery aspects of science, its hands-on nature, and the applicability of science concepts to everyday life. Some were discouraged by the lack of time and resources, the often tedious and repetitious nature of their science curriculum and science teaching, and their own lack of knowledge and difficulty of keeping abreast of new information. The most commonly perceived obstacle to integrating investigations into the classroom was lack of time, followed by lack of resources. Their greatest perceived needs for bringing energy investigations into their classes were materials, space, time, new curricular ideas, and training.

Teachers assigned the highest importance ratings to availability of materials and resources, gaining content knowledge, comfort level with conducting open-ended investigations, cooperative learning strategies, and networking with other teachers and scientists. Teachers assigned the lowest importance to support needed from workshop leaders and working with scientists.

Nine scientists returned pre-institute surveys (Table 3). Scientists' goals for participating in the institute were to learn more about the needs of teachers and inquiry instruction and to make science more accessible and usable for the non-scientific public. Seven scientists had worked with teachers previously and reported positive experiences; they were highly interested in working with teachers on curriculum topics in their fields, but none were familiar with teaching methods for middle and high school. Lack of knowledge about the needs of students was noted as an obstacle for integrating investigations into school curricula. Scientists gave highest importance ratings to improving teaching skills, teaching about the scientific method and inquiry, learning how to work successfully with teachers, and ongoing support and communication with institute leaders.

Post-institute Surveys. All participants reported that they valued teacher-scientist collaborations highly (Table 4). Institute materials (e.g., publications on energy education and inquiry teaching, and energy investigation kits), discussions on partnerships and inquiry teaching, collaborative planning time, and inquiry-based investigations used in the institute also were given very high ratings. Discussions of content standards for energy education and research presentations by scientists were rated only as moderately important.

Most participants were very positive about the inquiry and collaborative aspects of the institute (Table 5). They cited increased appreciation for inquiry learning and confidence in their abilities to lead inquiries as a result of the institute. The issue of time was still acknowledged as an obstacle to implementing inquiry strategies in their classrooms. Facilitating communication with scientists was suggested by several teachers as essential to continued collaboration and use of inquiry.

Institute Observations. Narrative descriptions from the early portion of both institutes indicated that group work often was dominated by scientists and male teachers in the groups. Recorders reported: *"[Scientist] and male teacher working; three female teachers watching"*. However, by the second day of the institutes fewer participants were in passive roles and more true collaboration was observed: *"[participants] were much more relaxed* *and comfortable with the challenge... Scientists did not dominate at all...There was a lot of great discussion going on within groups".*

Interviews. Of the four teachers in the 1996 institute, three had used inquiry-based lessons on energy after the institute. One teacher led three different inquiries, and gave high ratings (on a scale of 0-4) to student interest levels (3/4), inquiry levels (3), and success of the lessons (3). This teacher planned to use the investigations again, and had been in contact with two participating scientists following the institute. A second teacher used a variation of an inquiry developed during the institute. This inquiry was more guided than those presented in the institute, and the teacher rated the students' interest and the success of the lesson as low (0). The teacher thought the lack of success was largely due to the low motivation of the students involved, and planned to use the lesson again with a different class. A third teacher presented one of the energy inquiries developed for the MORE institute at the Montana Educator's Association 1996 Conference. Based on the response received, this teacher felt it was highly successful. All three of these teachers planned to use the lesson again. The fourth teacher had not yet reached the energy portion of the school's curriculum.

Only one teacher interviewed had been in contact with scientists following the workshop, although two others were interested in doing so. They cited lack of time as the greatest obstacle to making contact. All supported the use of inquiry in their classes, and felt more comfortable using it in smaller classes, and with certain age groups. Three teachers felt "very comfortable" using inquiry instructional strategies; the fourth felt "somewhat comfortable".

Two of the six scientists interviewed after the first institute had been in contact with teachers; both arranged field trips to an energy site in Montana. The other four scientists from this institute remained interested in working with teachers. Time and distance were given as the primary obstacles to collaborating with teachers, along with the difficulty of making their research relevant to students. Five scientists thought "hands-on" activities were appropriate for middle and high school classes. They suggested field trips to research sites, computer or lab exercises, and interactive home pages would facilitate integration of their research into classrooms. Most scientists felt "very comfortable" with using inquiry, and all believed that teacher-scientist collaborations were worthwhile for energy education. Moreover, they were very enthusiastic about being involved in precollege classrooms, stating that *"students will benefit from such partnerships"*.

Summary. Did the institute facilitate partnerships between teachers and scientists? In the pre-institute surveys teachers gave low importance ratings to the support they needed from workshop leaders and working with scientists. Post-survey data show that teachers and scientists both highly valued teacher-scientist collaborations. This outcome was particularly supported by interviews with scientist. Scientist stated their enthusiasm about being involved in precollege classrooms and how students would benefit from these interactions.

One additional area of interest which developed from the design of the institutes was the consistent change of the group dynamics from male and scientist dominated working groups to more of an equitable status for all participants. This could be attributed to placing men and women in inquiry focused activities out of the direct expertise of any individual, and not allowing scientists to share their expertise until the end of the institute.

Goal 2: Inquiry Teaching in Energy Education

Classroom Observations. IQ data were collected in 10 pre-institute classes and 9 post-institute classes. Average scores were higher for post-institute classes in all categories (Table 7); however, none of these differences was statistically significant. Two observers collected these data independently, and average scores were significantly different for the two observers ($P < 0.005$) in all categories. Observer biases may have affected results, since the observer that tended to give higher scores also observed more pre-institute classes. When effects of both observer and time of survey (pre- or post-institute) were analyzed simultaneously using ANOVA, only observer had a significant effect. A larger sample is needed to show clear results for this somewhat subjective test.

Qualitative descriptions of these classes also were made. Overall, the observers reported mostly positive comments about questioning techniques and teacher behavior in pre-institute classes: *"She used both divergent and convergent questions well"; She gave clear instructions and fielded questions calmly"*. The lessons and student behavior received less positive comments: *"This was a very guided lab"; "The constant distractions certainly impaired the lesson"*. When we observed teachers implementing energy inquiries after the institute, the narratives noted higher inquiry levels in the lessons and improved student behavior: *"Each group had complete freedom in the design..."; "[The teacher] spent far less time in this lesson on discipline (15%) than in the first class I observed her teach (60%)"; "...almost everyone remained engaged throughout the whole class period"*.

<u>Student Collaborations</u>. The MCI was administered in 7 pre-institute classes and 5 post-institute classes to a total of 230 students. Scores for levels of satisfaction, competition, and cohesiveness all were significantly higher in post-institute classes (Table 6). Scores for perceptions of classmate friction and class difficulty were lower in post-institute classes, although this difference was not significant for the level of difficulty.

SLEI data were collected for 3 teachers before the 1997 institute and 1 teacher after the institute. Post-institute sampling was affected by the short time remaining in the school year after the institutes were implemented. Students generally were positive about their science laboratory environment. Average ratings by all students were highest for the level of topic integration (28.6) and student cohesiveness (28.1), followed by rule clarity (26.9) and material environment (26.6). Ratings for the level of open-endedness were much lower (average = 19.8). Because of the very small sample size, we did not compare pre- and post-institute classes.

Lesson Plans Thirteen teachers submitted lesson plans after the second institute; ten of these were implemented before the school year ended. All lessons incorporated hands-on activities for teaching about energy; the amount of inquiry in the lessons varied. Seven lessons used a very open-ended approach to inquiry. In these cases, the teacher offered only a general question or objective related to energy and possibly a variety of materials to use. The remaining six lessons used a guided inquiry approach, where teachers were more directive in how the students should proceed with their investigations. However, the questions in all these lessons were divergent and many design decisions were left to the students. Teachers gave very positive feedback on the lessons they implemented. One teacher wrote "*The lesson was a big success and with some fine tuning and integration into a larger unit it will definitely be a big asset to my students and me. The concept of inquiry worked very well. The students bought into the question and therefore learned a great deal more from the solution.*" Comments from other teachers included "*The kids' interest and active participation remained high throughout. The open inquiry was successful...*" and "*I think the lab went extremely well...once they [students] got started, they really were thinking about how to best complete the lab.*"

Some teachers who did not submit lesson plans supplied information on post-institute collaborations with scientists, and lessons they used incorporating inquiry. At least seven teachers had collaborated with scientists on energy education projects after the institute, and at least one scientist visited a school to work with a class. In addition to the thirteen teachers who submitted lesson plans, at least four others led hands-on activities related to energy; three of these were inquiry-based.

Summary. Did the institute increase teachers' use of inquiry teaching in energy education? IQ data suggest a change in teaching strategies. While no statistically significant differences were measured using the IQ questionnaire, all mean scores recorded of teachers classrooms after the institute were higher. Observations of teachers' classroom learning environment support the tentative IQ data. Observations indicated students experienced more open-ended lessons, had less disciplinary problems, and found students more engaged. The strongest quantitative data came from the MCI questionnaire. Students' perceptions of the classroom learning environment changed significantly regarding the criteria of lesson satisfaction, competition, and cohesiveness. While these criteria do not in them-selves define an inquiry classroom learning environment, they do indicate that students enjoyed the lessons taught and that students were involved in positive group dynamics. Submitted lessons plans indicated on paper a wide degree of open-ended to guided inquiry approaches. Teacher comments were consistently positive about the success of the activities and their positive perceptions of students' learning and enjoyment regarding the lesson.

Conclusions

Assessment data demonstrate that the *Teaching About Energy Through Inquiry* institute was successful in facilitating teacher-scientist partnerships and increasing the use of inquiry in science teaching. During the institute, participants learned to collaborate on science education projects, and collaboration continued after the institute. Participants viewed interactions very positively. Satisfaction with collaborations was probably due in large part to the nature of the institute environment, which stressed equal status for teachers and research scientists (e.g., as recommended by Feazel and Aram 1990) and the two-way exchange of expertise. Small group work on engaging projects which used low-tech, commonly available materials helped participants to overcome their reserve and establish a personal basis for collaboration.

The institute was successful in addressing several issues rated of great importance or concern by participants before the institute. Participants reported satisfaction that many of the issues of concern identified in pre-institute surveys (e.g., materials and resources, collaboration, and using inquiry) had been addressed.

Most teachers used inquiry-based investigations in their classes after the institute, and gave positive feedback on those lessons. Information from student surveys demonstrated that their satisfaction with their science classes was greater during inquiry-based lessons than in the lessons they completed before the institute. It is unknown what the long-term effects of such collaborative efforts will be on classroom environments.

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Table 1a. Post-institute interview questions asked of teacher participants.

1. Have you been in contact with or worked with any MORE research scientists since participating in the workshop?

*If yes, please describe the nature and level of this interaction. Was it a positive or negative experience? Why?

*If no, are you interested in working with scientists to integrate their research into your classroom? Why or why not?

What do you see as the main obstacles to working with scientists and/or integrating their research into your classroom?

2. Have you had the opportunity to teach the inquiry-based lesson(s) developed at the MORE workshop?

If YES:

a. Please describe the activities implemented. What was the topic, duration of lesson, number of participating students, etc.?

b How would you rate the successfulness of the lesson -

0	1	2	3	4
not successful		somewhat successful		very successful

c. Were students required to design their own experiments to solve a problem you presented or did you give instructions on the appropriate methods for conducting the experiment?

d. Were students allowed to go beyond the regular laboratory exercise to experiment on their own, if any wished to?

e. Please rate the extent to which the lesson offered a variety of levels and paths of investigation.

0	1	2	3	4
one level & path of investigation		some lesson variety		all students able to pursue own direction

f. Did you introduce concepts before or after the direct experiences?

g. Please rate the students' level of interest in this activity.

0	1	2	3	4
bored		mildly interested		very interested

h. What type of assessment did you do for this lesson? A test or otherwise? How did their performance compare with that on other tests or assessments?

i. Do you plan to use this lesson again? Why or why not?

If NO:

a. Why haven't you used it?

b. Do you plan to use one in this school year? When?

3. How comfortable did you feel using the inquiry method? (please rate)

0	1	2	3	4
Not comfortable		somewhat comfortable		very comfortable

4. Do you support the use of the inquiry method in other classes? Why or why not?

5. Do you have any other comments or concerns about the workshop and its outcomes?

Table 1b. Post-institute interview questions asked of scientist participants.

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1. Have you been in contact with or worked with teachers since participating in the workshop? If yes, briefly describe the nature and level of your involvement. Was it a positive or negative experience? Why?

If no, are you interested in working with teachers on curriculum topics relevant to your scientific field? Why or why not? What do you see as the main obstacles to working with teachers?

2. What teaching methods do you see as appropriate to the High School and/or Middle School classroom?

3. How can your research be or how has your research been most effectively integrated into the High School or Middle School science classroom?

4. What is your comfort level with inquiry-based learning? How would you rate your level of comfort in conducting open-ended science investigations with students?

5. Are teacher/scientist collaborations worthwhile in developing and integrating energy education in the High School and/or Middle School classroom? Why or why not?

6. Do you have any other comments or concerns about the workshop and its outcomes?

Table 2. Responses by participating teachers to pre-institute survey questions.

QUESTION AND RESPONSES	# TIMES RESPONSE WAS GIVEN
Is there something about science that excites you?	
• Discovery, experimentation, newness	9
• Hands-on nature	5
• Applicability to everyday life	4
Is there something about science that turns you	
off?	8
• Lack of time and resources	5
• Tedious and repetitious nature	2
• Lack of knowledge	
Your primary goal for participating in workshop?	
• Learn new, hands-on teaching methods	14
• Learn more about inquiry	6
• Learn more content knowledge	5
What will be the greatest obstacles for integrating energy investigations into your curriculum?	
• Time	15
• Lack of resources	8
What do you foresee as your greatest need for bringing	
energy investigations into your classroom?	5
• More materials and space	4
• Time	2
• New curriculum	2
• Training	

Table 3. Pre-institute ratings of issues related to energy education. Issues were rated on a Likert scale of 1 (not important to me) to 5 (of great importance to me).

TOPIC	RESPONSE (x)
Teacher surveys (n = 29)	
Availability of materials	4.76
Resources	4.41
Gaining content knowledge	4.38
Comfort level with conducting open-ended investigations	4.17
Cooperative learning strategies	4.03
Networking with other teachers	4.03
Networking with scientists	3.90
Alternative assessment	3.83
Ongoing support from workshop leaders	3.69
Working with scientists	3.62
Learning cycle and scientific method	3.45
Scientist surveys (n = 9)	
Working successfully with teachers	3.89
The scientific method and inquiry	3.78
Support network for teachers	3.78
Improving teaching skills	3.75
Ongoing support from workshop leaders	3.56
Comfort level with conducting open-ended investigations	3.50
Adequacy of research site for class visits	3.22

Table 4. Average post-institute ratings (on a scale of 1 to 5) of importance of workshop activities. Mean response values did not differ significantly between teachers and scientists (P > 0.05 for all, Mann-Whitney U).

ACTIVITY	TEACHER RESPONSES x (n = 26)	SCIENTIST RESPONSES x (n = 12)
Collaborating with scientists	4.6	4.5
Collaborating with teachers	4.6	4.3
Institute materials and resources	4.4	4.4
Discussions on teacher-scientist partnerships	4.2	4.0
Group discussions of teaching plans	4.2	4.5
Collaborative planning for inquiries	4.1	4.1
Discussion of barriers and solutions to using inquiry	4.1	4.3
Energy investigations	4.0	4.0
Introduction to inquiry	3.9	4.1
Central questions in energy education	3.9	3.6
Scientist presentations of research	3.5	3.3

Table 5. Most frequent responses given to open-ended questions from the post-institute survey.

QUESTION AND RESPONSES	# # TIMES RESPONSE WAS GIVEN
What did you appreciate about the Institute?	
· Inquiry activities	10
· Group discussions	7
· Reference materials	7
Describe changes in knowledge, skills, and attitudes about teaching through inquiry as a result of your institute experience.	
· Greater understanding of benefits of inquiry teaching	11
· More excited and confident about teaching with inquiry	8
Describe your comfort level with integrating an inquiry approach into your teaching.	
· Very comfortable	11
· Somewhat comfortable	10
· Uncomfortable	2
What was your impression of the effectiveness of the scientist/teacher collaborations?	
· Excellent/very effective	12
· Good	10
· Needed more time with scientists	6
Would you like to continue the scientists/teacher collaborations started during the institute? If yes, what can institute organizers do to facilitate interactions?	
· Yes	17
· Compose a list of addresses & e-mail addresses	8
What types of follow-up activities are needed to ensure that ideas developed in the institute can be implemented during the next academic year?	
· Communication (newsletter mentioned several times)	11
· Assistance from a scientist	4
For teachers: What are the obstacles to integrating energy inquiries into your curriculum?	
· Time	18
· Supplies	8
· Space	6

Table 7. Comparison of pre- and post-institute I.Q. scores for teachers participating in the *Energy Inquiry Institute*.

SCALE	PRE-INSTITUTE MEAN (n = 10)	POST-INSTITUTE MEAN (n = 9)	P[1]
Lesson	2.84	3.28	0.23
Student Behavior	2.16	2.87	0.14
Teacher Behavior	2.68	2.89	0.62
Questioning Techniques	3.02	3.46	0.66
Composite	2.81	3.10	0.35

[1]P-values of Mann-Whitney U test of ranks.

Table 6. Comparison of pre- and post-institute MCI scores from classes of teachers participating in the *Energy Inquiry Institute*.

SCALE	PRE-INSTITUTE MEAN (n = 148)	POST-INSTITUTE MEAN (n = 84)	P[1]
Satisfaction	*8.86*	*10.75*	*0.000*
Friction	*10.72*	*9.46*	*0.010*
Competition	*10.76*	*11.74*	*0.018*
Difficulty	*7.44*	*7.30*	*0.816*
Cohesiveness	*6.76*	*7.42*	*0.139*

[1]*P-values of Mann-Whitney U test of ranks.*

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