NSF MSP LEADERS Project

Evaluation Report

Year Four

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Prepared

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This report summarizes the activities and finding of the evaluators of the NSF MSP project at The University of Toledo entitled LEADERS from June 2012 through May 2013.

Executive Summary

Some changes based upon alterations in project design, data collection response rates, and recommendations of the external evaluation advisor were made to the Year 4 evaluation plan. Of significance was the replacement of the Horizons Inside the Classroom Observation protocol and the Teacher Leader PBS interviews and definitions with in-depth case study observations that allowed the evaluation team to gather more comprehensive information as to the extent to which project based science (PBS) was incorporated into the Teacher Leader (TL) science classroom.

The TLs continued to grow as leaders over the past year. A repeated measures analysis of Cohort 1 showed statistically significant increases in scores on both scales of the Science Teacher Efficacy Beliefs Instrument (personal beliefs—the belief one can provide quality science instruction—and outcome expectancy—the belief that quality science instruction can improve student learning). Cohort 2 did not show a statistically significant change between their first two years on this instrument. TLs in both cohorts showed a preference for inquiry based instructional strategies over more traditional instructional strategies (1.7 to 1 for Cohort 1; 1.26 to 1 for Cohort 2) as determined by responses to the Science Teacher Ideological Preference Scale. Responses to the LEADERS Leadership Inventory, designed to examine TL responsibility for, comfort with enacting, and knowledge of specific leadership tasks associated with the goals of LEADERS showed increases in all areas for both cohorts. In particular, the number of TLs that responded with the highest ranking ("a great deal") increased statistically significantly using a chi square goodness of fit analysis that pitted last year's results (expected) with this year's (observed).

Case studies illustrated that while teachers either struggled with or held back with PBS lessons in the fall, spring observations showed improvements. While the comprehensive implementation of PBS was rarely observed, TLs became more confident and prepared in their delivery of a PBS unit. During fall observations, students often seemed lost as to what was expected of them but during spring observations students seemed comfortable with the process. It is important to remember that while teachers may learn how to provide effective PBS instruction, if students are uncomfortable, do not know what to expect, or are unfamiliar with the process, implementation can be inhibited. Over time, as students become more familiar with PBS, teachers can spend more time on the lesson itself and less time teaching students how to work in groups, how to investigate a science problem, and how to work towards defining problems and developing solutions. Future professional development sessions should include strategies for familiarizing students to the process and perhaps scaffolding PBS in such a way that students grow comfortable with the process over time.

As in previous years, district teachers rated the LEADERS professional development (PD) sessions hosted by TLs highly and appreciated the access to science resources. Focus group interviews were conducted with Cohort 2 district teachers. In general, they liked the format although the teachers in Monroe district (participating in PD for the first time) indicated it took some time to adjust to the “philosophical switch.” They felt the PDs to be relevant to their teaching and some indicated participation in the PDs has changed the way they approach content.

Cohort 2 TLs completed the professional networking survey (SNA) in May 2012 and again in December 2012. A comparison between testing (6 months) showed that in this short amount of time the Cohort 2 TLs have changed their support network. In general the TLs have shifted from relying solely on district support to expanding to the use of LEADERS supports including the network coach, other TLs, and university science faculty. Of significance was the creation of professional learning communities among the TLs.

As with previous years, content courses taught during the Summer Institute resulted in substantial (statistically significant) gains on tests of content knowledge. In addition TLs were satisfied with the courses ranking them consistently in the “good” to “very good” range. Cohort 1 participated in an end of program focus group interview. They found the courses offered during the Summer Institute to be challenging and the content was useful to them in their role as both a teacher and a TL. Science Café is an appreciated resource but cumbersome. They would like information it stores be considered for a more public website that can be accessed by the TLs and their district teachers. If possible, they recommended Assessment course be offered Year 3 and Social Foundations Year 2 for Cohort 2. The TLs left their final Summer Institute feeling confident in their abilities to serve as TLs and provided concrete examples of the positive effects of the PD they delivered.

Cohort 2 also participated in a focus group interview. Difficulties experienced during Cohort 1’s first year have disappeared. All agreed that they had a clear idea of what their next steps as a TL will be, they felt prepared to carry out those responsibilities, and they were confident they can implement project based science in their classrooms.

There is little specific data to report for effects on district science teachers. Data collection efforts have fallen short of expectations—so minimal that analysis of findings will not reflect the population. However, the Toledo Catholic School district has, as a result of involvement with LEADERS, adopted a problem based learning model for the entire Diocese so inquiry based learning takes place not only in the science classroom but with every subject.

As in previous years, data collected at the student level did not show differences between treatment and control groups. Measures were taken on the Ohio Achievement Science Test passing rates, the project-developed Student Attitudes About Science instrument (grades 3 – 9; analyzed at the 3-4, 5-6, and 7-9 grade levels), and a content test on renewable energy (grades 6 and 8 analyzed by grade).

Members of the LEADERS partnership representing local renewable energy business and industry met for a focus group interview in April 2013. Members illustrated a sound understanding of LEADERS goals and activities and provided examples of their involvement in the project. Many organizations hosted field trips or “loaned” an expert to visit a classroom. Others provided science materials to classrooms. The partners were aware of difficulties of field trips including the cost of transportation, the time the trip takes away from the business, and hosting trips to minors when facilities may be dangerous.

The business partners shared a positive impression of the TLs and their efforts. They noted that the TLs were knowledgeable and even some of the more veteran teachers showed a renewed vigor. The network and transference of ideas and information is cause for hope among the business partners regarding the future of education in the area. The sentiment was echoed that there has to be a better way to make the information available to all teachers and not just the one or two who contact the business for information or tours. The conversation concluded with a consideration of how technology could be implemented to bring this information to the teachers and students. The partners were positive about their relationship with the project and were looking forward to continued work with local school districts.

The project has achieved many goals for Cohort1. At the conclusion of their participation, they, as a group, have assumed leadership responsibilities within their districts. They have also changed the way they teach science to incorporate many if not all principles of PBS. Each year Cohort 2 TLs are becoming more knowledgeable, more confident, and more proficient in the delivery of quality renewable energy and project based science professional development. Positive effects on district teachers were evidenced by their feedback after PD sessions. While measures of students do not show statistically significant gains of treatment over control students, there are many factors that affect these outcomes including student and teacher transiency (thereby confounding control and treatment groups) the relative short period of time the project has been in place, and competing professional development and continuing education programs.

I. LEADERS Evaluation Model

There were slight changes in the data collection plan Year 4. District teachers were again surveyed in the fall and students were assessed in October and May to examine change over time. The addition of Cohort 2 added a few logistical hurdles as the Monroe School District is spread out over a larger geographic area than the districts in Cohort 1. Teacher Leader (TL) professional development workshops for district teachers were again spread out throughout the year. Evaluation feedback was collected from the district teachers who attended during the first and last sessions. Cohort 1 completed just the surveys—Cohort 2 also participated in focus group interviews at the conclusion of the last session. Instead of conducting isolated observations using the Horizon Inside the Classroom Observation protocol, in depth case studies of five Cohort 1 TLs were conducted to gain a clearer picture of TL understanding of Project Based Science (PBS).

Social network analysis (SNA) was again used to examine TL networks. Depiction of the webs was altered to better reflect comparisons.

Last year, classroom observations of district teachers as a measure of the effectiveness of the PBS workshops was eliminated due to difficulty determining the extent to which TLs and district teachers have mastered project based science (PBS) using the Horizon Observation Protocol as our instrument of measurement. As a replacement, this year we provided incentives to district teachers to allow us to view them conducting a lesson in which content and strategies learned from the PD was included. We followed the observation with an interview about what they understand about PBS.

The *Levels of Leadership Assessment* that we hoped to incorporate into our evaluation design Year 4 is still under development. The LEADERS research team has assumed the lead in developing and validating this instrument with the expectation that it will be used during Year 5. The instrument aligns with the seven domains of the Teacher Leader Model Standards (http://www.teacherleaderstandards.org/index.php), which has guided the Summer Institute (SI) leadership classes.

II. TEACHER LEADERS

This section includes data collected from Cohort 1 and Cohort 2 TLs. Quantitative instruments coupled with personal interviews and observations were employed to measure change in TL attitudes, confidence, and ability. Results concerning content mastery gained from the Year 3 Summer Institute are included in this report as the Institute took place July 2012 and Year 4 data will not be reported until next year. Other instruments included are the Science Teacher Efficacy Beliefs Instrument (STEBI), the Science Teacher Ideological Preference Scale (STIPS), the project-developed LEADERS Leadership Inventory (LLI), and the project developed LEADERS TL Social Network Survey. Responses to personal interviews and results of PBS lesson observations are also included. To uncover the extent to which TLs understand and implement PBS, five in depth case studies were conducted with Cohort 1 TLs.

A. Science Teacher Efficacy Beliefs Instrument

The STEBI (Enochs and Riggs, 1990) was again employed as a measure of TL development. There are two subscales. Outcome expectation is the belief that what is done will have a positive effect. Coupled with outcome expectation is the confidence that the person can perform the action successfully. This is the self-efficacy expectation (or personal beliefs). High scores on each scale suggest a high level of self-efficacy in science teaching and suggest that the teacher leaders are more likely to pursue LEADERS goals of providing science teachers with quality professional development in the integration of renewable energy science into their classrooms using PBS.

Several statistical methods were employed to examine change in scores on the two scales from 2010 through 2013. To improve the data analysis, Rasch Modeling was used to convert ordinal responses into interval scales so that parametric analyses could be performed. The 2010 to 2013 data was anchored with the baseline (district teacher's, i.e., population) data to determine changes. The repeated measures ANOVA was conducted to examine changes in mean scores of outcome expectancy and personal belief scales for Cohort 1. A paired t test was performed to examine change in Cohort 2. Tables 2 and 3 provide results of the analyses.

LEADERS Revised Evaluation Model

Modifications to the plan are in bold print.

Table 1: LEADERS Year 3 Evaluation Outcome Measures

Goal	Outcome	Measure	Source	Frequency
1, 2, 3	Increased knowledge of PBS	PBS lessons scored with rubric	Project developed	annually
1, 2, 3	Increased knowledge of PBS	*Direct observation—case studies	Evaluator	annually
1-5	Impact of partnership on leadership development	Social network analysis survey	Evaluator	annually
1-5	Impact of partnership on other partner organizations	Social network analysis survey	Project developed	annually
1-5	Implementation of PBS (teacher leaders)	*Direct observation—case studies	Evaluator	**revised collected annually**
1-5	Implementation of PBS (teachers in district--random sample)	*Classroom observations/interview	Evaluator	r**evised collected annually**
1-5	Teacher leader self-efficacy in teaching PBS	STEBI & STIPS	Evaluator	annually
1-5	District teacher self-efficacy in teaching PBS (random sample)	STEBI & STIPS	Evaluator	**revised deleted**
1-5	Improved leadership skills	Leadership survey based on Performance Expectations and Indicators for Education Leaders	Project developed	annually
1-5	Improved leadership skills	Level of Leadership Assessment	Project developed	**under development**
1-5	Understanding and implementation of PBS	*Direct observation—case studies	Evaluator	**revised collected annually**

3 & 5	Improved student learning	Ohio state achievement tests in science	School districts	annually
3 & 5	Student interest in learning science and pursuing science careers	Survey	Evaluator	annually
3 & 5	Improved student learning	Renewable energy content tests	Project developed	Pretest/posttest
5	Impact of MSP on IHE faculty	Data collected from national MSP annual survey	Program developed	annually
5	Impact of MSP on informal science partners	Survey covering programmatic changes, understanding of state content areas, degree of collaboration with community and policy changes as a result of participating in MSP	Project developed	annually
5	Impact of MSP on science-related industries	Interview with business partners	Project developed	**revised collected annually**

No statistically significant changes on either scale occurred during the first year of participation for Cohort 2. Next year a repeated measures analysis of variance will be performed to determine change over three years of participation.

Table 2: Repeated Measures ANOVA of STEBI Cohort 1

	Mean	Standard Deviation	Repeated Measures			
STEBI Personal Beliefs			Within		Between	
2010	46.15	4.59				
2011	47.89	8.46				
2012	52.60	6.82				
2013	46.80	3.59	F = 1.52	P = 0.24	F = 2337.41	p < 0.001
STEBI Outcome Expectancy			Within		Between	
2010	35.41	18.85				
2011	46.75	11.55				
2012	48.57	22.02				
2013	45.61	1.37	F = 33.17	P = 0.01	F = 347.20	p < 0.001

Table 3: Paired Sample t Test of STEBI Cohort 2

	Mean	Standard Deviation	Paired T-test
	Mean	Standard Deviation	
Cohort 2 Personal Beliefs			
2012	42.84	8.67	
2013	45.02	4.04	t (17) = 0. 18; p = 0.86
Cohort 2	Outcome	Expectancy	
2012	50.22	11.43	
2013	44.74	1.86	t (17) = 0. 36; p = 0.72

B. Science Teacher Ideological Preference Scale (STIPS)

The STIPS provided a measure of science teacher preferences for inquiry-based versus more traditional (non-inquiry based) instructional strategies and procedures. Preferences are reported in a ratio of inquiry based instructional practices to traditional science teaching practices. As in the previous year, the STIPS scores were converted to an interval scale using Rasch modeling and recalibrated using district teacher responses as anchors. Last year Cohort 1 TLs showed a 1.8 to 1 ratio in favor of inquiry based instructional strategies. This year the preference for inquiry based instruction dropped slightly to 1.7 to 1. Cohort 2 established a baseline ratio of 1.5 to 1 last year. This year's preference for inquiry over non-inquiry strategies dropped to 1.26 to 1. In general, however, the TLs continued to prefer inquiry strategies over non-inquiry strategies.

C. LEADERS Leadership Inventory (LLI)

The LLI determines the amount of leadership responsibility the TLs have for specific duties associated with teacher leadership and the LEADERS project and then explores how comfortable the TLs feel engaging in these same activities. The scales use responses ranked 1 through 5 with a 5 indicating more positive responses. To analyze this survey, frequencies of responses over 2 (where 3 = some, 4 = a moderate amount, and 5 = a great deal) were calculated and compared to determine whether the TLs reported more responsibility and more confidence carrying out leadership responsibilities over time. Table 4 illustrates the number of positive responses (3, 4, or 5) for each construct. As can be seen, Cohort 1 responses indicate that 92% have science education leadership responsibilities, 77% felt confident in enacting those responsibilities, and 97% felt they have the knowledge to do so effectively. Slightly over 81% of Cohort 2 indicated they have science education leadership responsibilities, 98% felt confident carrying them out, and 82% felt they have the knowledge to carry out their leadership responsibilities.

Table 4: Summary Statistics of TLs Survey for Cohort 1 and Cohort 2 (2013)

	Responsibility	Confidence	Knowledge
Cohort 1 n = 7			
Sum	74	77	97
Percentage	92.2	100	97.9
Cohort 2 n = 11			
Sum	95	121	131
Percentage	81.1	97.5	81.9

Cohort 1 responded with a 3, 4, or 5 to the **leadership responsibilities** 74 times (reduced from the 81 responses in Year 3). Noteworthy, however, is the change in response category. In Year 3, Cohort 1 responded "some" 54 times compared with only 14 times during Year 4 and, correspondingly, Cohort 1 did not rate any responsibilities "a great deal" (the highest ranking) in Year 3 but responded with that ranking 27 times during Year 4. A chi square goodness of fit test using Year 3 responses as expected frequencies resulted in a statistically significant change in responses "some" (much lower than expected in Year 4) and "a great deal" (much greater than expected in Year 4) for Cohort 1 ($\chi^2 = 29.58$, df = 4, $p < 0.0001$). Table 5 delineates Cohort 1 responses by responsibility and response.

In Year 3, Cohort 2 only indicated some degree of responsibility 19 times with one response as "some" and 18 responses in the "moderate" category. In contrast, Year 4 included 106 positive responses to holding some level of responsibility for leadership in science education. Distribution of responses included 36 in the "some" category," 41 in "moderate," and 29 in "a great deal" of responsibility. Again a chi square test indicated that TLs increased their level of responsibility at statistically significant rates ($\chi^2 = 1618$, df = 4, $p < 0.0001$). The distribution of responses for Cohort 2 is provided in Table 6 below.

Table 5: Cohort 1 Teacher Leader Leadership Responsibilities

Area	Some responsibility	A moderate amount	A great deal
Organizing and facilitating professional learning communities for science educators	0	3	4
Working with science educators to determine their professional learning needs	0	4	3
Designing customized professional learning opportunities and programs for other science educators	0	4	3
Coaching or mentoring other science educators	1	3	3
Being an advocate for science activities and strategies	0	2	5
Representing your school and district at professional meetings and conferences	0	3	4
Assessing the effectiveness of professional learning programs and processes for educators	3	2	1
Providing resources and research related to science reform to other educators	1	5	1
Working with scientists and industry partners	3	2	0
Involving parents and the community in enhancing science education	5	1	1
Providing energy-related content support to other science educators	1	4	2
Totals	**14**	**33**	**27**

Table 6: Cohort 2 Teacher Leader Leadership Responsibilities (N=11)

Area	Some responsibility	A moderate amount	A great deal
Organizing and facilitating professional learning communities for science educators	2	5	4
Working with science educators to determine their professional learning needs	2	4	4
Designing customized professional learning opportunities and programs for other science educators	2	5	4
Coaching or mentoring other science educators	3	4	4
Being an advocate for science activities and strategies	2	5	4
Representing your school and district at professional meetings and conferences	5	5	1
Assessing the effectiveness of professional learning programs and processes for educators	3	4	1
Providing resources and research related to science reform to other educators	3	4	3
Working with scientists and industry partners	5	2	0
Involving parents and the community in enhancing science education	3	2	2
Providing energy-related content support to other science educators	6	1	2
Totals	**36**	**41**	**29**

D. PBS Understanding

1. Case Studies

Based upon the recommendation of the evaluation advisor (Koch), we supplemented the PBS survey with an in-depth case study of a sample of TLs from Cohort I. Seven of the Cohort I teacher leaders were chosen to participate in case studies to better understand the impact of LEADERS on their understanding and use of PBS pedagogy. Of the seven, evaluators could coordinate with only two TLs to observe their teaching both fall and spring semesters as designed. Case studies utilized four data sources: lesson plans, interviews, observations, and student artifacts. The data were analyzed collectively to provide a substantive and summative evaluation of their PBS knowledge and skills after three years of intensive study and PD delivery through the LEADERS Project. The case study methodology is provided in detail in the Appendix.

a) Teacher A: *Fall 2012*

The following is the overview of the unit taken from this second grade teacher's plans:

> This long-term weather unit addresses all of the new second grade Ohio content standards for the topic "The Atmosphere." Students plan their own driving question (although they may be guided towards something similar to "How do we know what to wear to school tomorrow?"). Students digitally record a daily weather report that begins very simply with measuring temperature. However, the weather reports become longer and more detailed as students design and create their own weather instruments and decide more information that they would like to include in their report. The weather report is uploaded online daily for other classes in the building (or district) to watch. All of the 5E's in this inquiry-based unit are connected to learning about how students know what to wear for the weather.

During visits to the classroom, the observer did not see evidence of the digital weather report. In fact, during the post-observation reflection, the teacher admitted that this aspect of the unit was never implemented. During the period of observation (three visits) the class participated

in a project to design and create a weather vane to measure wind speed and direction. When reviewing what had been done so far, children did say that they learned to measure temperature. When asked how they measured temperature, one child responded, "We use our brains" and another that "we use a thermometer."

While the teacher has incredible classroom management skills, she over-estimated the degree to which the children could work independently. First she explained the instructions (students were given a copy). Students were required to explain what they designed and why. She showed them supplies (spread out over the floor) available to make the vane but encouraged them to include other available items. The teams took turns looking at the supplies to get a better idea of what they could use then the teacher designed a vane as an example and used items students did not have available so they would not copy her design. As the students worked on their design, many tried to use the supplies to work out their design rather than plan it out on paper. They held things together to see if they would fit. While this process was not what the teacher intended (she wanted a drawing first and then materials would be decided), at this age it is difficult for children to design something of which they have limited knowledge. The fact that they used a “tangible” design process did not detract from the lesson although the teacher was disappointed. At some point the teacher should have discussed why we plan before we build--how designing allows the team to share ideas. When asked what background the children had with regards to designing and building a wind vane, the teacher responded that they viewed a PowerPoint slideshow.

A major shortcoming of all of this teacher’s science lessons is that about 5 of the 13 students are pulled from the class for reading tutoring about halfway through the lesson (this happened at every visit). Apparently the teacher must schedule student tutoring during a subject other than math or reading.

The last thing the students did was discuss, in teams, a composite design. An interesting dilemma occurred in one group when the students did not want to share ideas but rather wanted to design something entirely new. At this age, guided discussions are important because the students have little experience collaborating. One group realized some aspects of a design might not work and tried different solutions and explained why they thought their ideas might work. However, soon the discussion trailed off to thoughts that were not really relevant or they focused on the esthetics (color) rather than function of the vane. Eventually they came to an agreement on a design that actually was close to something that might work.

During the second and third observations, students refined their vanes. The teacher guided the students through the process of revision: “What do you think needs improvement?” “How would you change your design to fix this problem?” Student thoughts have moved from aesthetics to functionality and mechanics. One group realized that a decoration on the top of the vane was too heavy so they removed it. The other group found a way to reattach the blades so they could spin.

One difficulty with introducing PBS to children who have little if any experience working in groups is the tendency of one child to dominate. For example, one girl kept bringing in new materials and proposing to use them in the same way as the other materials that did not work. She monopolized the problem solving until the teacher directed the students towards the other team members' ideas. It was then that they had a breakthrough in their design.

The children have a hard time talking about the vane without touching and almost manhandling it. One group destroyed their base during their discussion and one girl took the pipe cleaner part that held the directional piece in place so the group had to totally reconstruct their vane.

At the end of the third observation, the teacher told the observer that she was not going to pursue this lesson any longer and that there was no need to come back to her class. She operated under the impression that PBS can only be the “build the project” phase of the problem solving process. The wind vane project had little to do with the driving question and building one was more of a lesson in physics than weather science. The teacher appeared happy this lesson was over, that she did not feel it worked, and that she did not want the observer back.

Post-observation reflection: The teacher felt students gained great ground in collaborative learning and that once children learn to work together, the PBS lesson will be easier to implement. She also noted that the lessons took longer than anticipated. She implemented this lesson once before (last year) and upon reflection she realized that this year’s class struggled with critical thinking when compared with her class last year.

Spring 2013
The focus of this unit was force and motion. The driving question was “Can we make arcade games using force and motion for a student fair to raise money for the poor?” The topic during the first observation was gravity. Children were asked to identify whether gravity was a force that affected the arcade game their teams had created. This time the teacher had five smaller groups thereby allowing more children to participate in problem solving. Once the children understood that without gravity things would float, they easily identified how gravity affected their games (made the ball fall through the hoop on the basketball game; caused the ball to roll down the slant of the skee ball game). Each of the three spring observations began with a review and concluded with a reflection. During the second observation, students were asked to design and write instructions for an experiment to test gravity. While designing the experiment was easy for the students, writing explicit instructions proved challenging. Instructions were vague and missed steps. Students were not permitted to actually conduct the experiment thereby making the development of instructions particularly difficult.

This part of the lesson was way over their heads. Maybe a worksheet that had the specifics of conducting an experiment mapped out like “supplies needed” would have helped the children to organize their thoughts. The teacher rotated among the groups helping them to refine their instructions by pointing out where she was confused. Slowly the plans got better. The concept of controlling for variables was hard for students to grasp also. The real issue making this exercise difficult was that the students did not know why they were doing the investigation. The students did not have something they were trying to prove in mind. Answering a question like "What do you think would happen if I dropped two similar objects of different sizes? Will they fall at the same rate or different? If different, which would fall faster and why?” would have helped them focus and the teacher could have then asked them to prove their hypotheses.

Despite its shortcomings, the children were engaged in this activity. There was a lot of conversation about how they would conduct their experiments. Sometimes what they thought about was irrelevant to the topic—force and motion. The teacher needed to bring them back to the underlying purpose of the activity but the number of groups exceeded her ability to monitor each group.

The last observation occurred when the students were exploring magnets. One group had revised their arcade game to use magnets to catch metal "fish" so the teacher asked those students to discuss why and how they used the magnets. Then everyone had an opportunity to explore magnets using a variety of magnets and anything in the classroom. The experimentation portion was followed by watching a short video about magnets where the students learned that metal must have iron in it to be attracted to a magnet. Unfortunately, the five children who attended reading tutoring were not in class at that time. Students then got into groups and redesigned one of the games using magnets. When the children being tutored returned, they were asked to help during that phase but one group was finished and the others were well on their way so those being tutored were left out.

This teacher could have provided more direction/guidance to the students without jeopardizing the fundamentals of PBS. This might have eliminated some of the more frustrating aspects of implementing PBS and helped the students stay on task. The fact that a third of her class misses a good portion of science instruction on a regular basis is troublesome.

b) Teacher B: *Fall 2012*

The fall observations for this 8th grade class involved a unit on chemistry. From the teacher's own admission, the lesson was "quasi-PBS." The driving question was "How can we teach the periodic table to middle school students?" During the two observations, students worked in small groups to complete worksheets about chemistry, explored definitions and qualities of certain elements using the internet and created a resource for younger students based upon what they found. The students struggled with group work—often working alone while sitting together. The teacher noted in her post-observation reflection that the students resisted collaborative groups and she did not want to just throw them into PBS until they developed teamwork skills. While the lesson did not reflect PBS as designed, the teacher's reflection did provide evidence that she understood how PBS should be implemented.

Spring 2013

The spring showed improvement in student science learning and scientific investigation. The underlying theme of this unit was force and motion. During the first observation, the teacher had the class sit together on the floor as she took a mechanical mouse, pulled it back along the floor, and then released it to scurry away. She asked the students what made it go and some responses included "friction" and "inertia". One girl mentioned it was both to which another student responded, "What is your evidence and reasoning for that?" Students did not engage in group conversations such as this during the fall 2012 observations.

The goal of this unit was for students to learn about force and motion through the creation of a windmill. After spending several weeks learning about the fundamentals, students in groups of three or four designed a windmill which they then constructed and tested using an electric fan. Eventually the windmills were to lift a payload. During the second observation, everyone had their supplies and began experimenting with ways to use the supplies to create a windmill. The students enjoyed this. Some groups sketched a design first while others manipulated the supplies in ways to visualize the final product. In a couple of groups a leader emerged. These groups seemed to be more on task and more efficient. The groups where students worked independently or who just started putting things together seemed to be off task. Many of them pushed a wooden dowel through a Styrofoam cylinder with no obvious translation to a windmill. The teacher roamed the room to bring groups back to the goal--a wind mill that spins.

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Once a model was put together, students took their windmill to the fan to see if it turns. One group designed an interesting blade that was somewhat cupped. Students went through the process of trial and error, changing their designs based upon outcomes. This day was the very first step and modifications would continue for the next month or so. Several models began to spin but not very swiftly. It was interesting to observe how disappointed the students were when their mills did not turn. They assumed because the model resembled a windmill it would operate like one suggesting that they have had little experience trying to create something. When using materials they are familiar with, students tended to use them in the traditional form rather than innovative ways based upon properties. Students all assumed the wind has to blow straight on until one group discovered that perhaps their windmill might work better with a side wind. The teacher gave subtle hints--if your blades are not turning, what forces are at play; draw the phenomenon. Eventually, students were able to create successful windmills that could actually raise a weight.

The spring observations provided evidence not only of teacher understanding of PBS instruction but also the gains students have made with regards to scientific investigation. The windmill lesson would have been disastrous had it been given in the fall. A key to successfully implementing PBS is knowing when students are ready to take over the investigation.

c) Teacher C: *Spring 2012* (note: It was difficult to schedule observations with this teacher and observations were made only in the spring)

Three observations took place at an inner city high school (juniors and seniors). The course was Environmental Science. During the first visit, the lesson involved the students working on a project concerning energy-efficient homes. The students were asked to build scale models of an energy-efficient designed home. The designing of these homes was the first step in the process. The designs were to be created to not only show the layout of the home, i.e. placement of the kitchen, bathroom, bedrooms, etc., but also where and in what form the energy efficient elements were to be implemented. During the observation, the students worked in teams of two or three and were actively building their model homes.

During the second observation, the first assignment involved the students documenting their activities from the previous day in their journals. After this, two different goals were part of this day's discussion: 1) Collect and report on CO_2 data levels at different locations in the school using various scientific instruments, and 2) continue to build model homes that were to emulate various aspects of energy efficient building practices. After a brief discussion about the assignments, the students broke into groups of two to four and were given a lot of leeway to complete the assignment. In the case of taking CO_2 reading throughout the school building, students were almost entirely self-directed and they did very well visiting different classrooms and using the instruments to collect the CO_2 readings. However, there was no link between the collection of the CO_2 readings and the home design so it was unclear why students were broken into two different tasks. While the students involved in the model home building activity also worked independently, there was opportunity for these students to interact with the teacher and receive guidance with regards to implementing different aspects of their design.

During a different visit, the class engaged in a discussion of the CO_2 data collection process. This class was the most substantive aspect of any of the classes observed. After a brief discussion about the results of the previous day's activities, the teacher pointed out there were problems with the data in terms of consistency. A wide variety of readings were taken, somewhat dependent on the scientific device the students used to collect the data, but also based on the individual student groups, their knowledge of the instrument and the procedures used to collect the data. This led to a discussion about student data collection methods and what they could do across groups and between groups to eliminate any inconsistency in the process. The class to came up with a list of procedural rules that were to be implemented in the data collection process, such as: (1) without disturbing the class where the CO_2 was measured, take readings in the middle of the classroom; do not take readings near the doorway; and document the classroom activities where the readings were taken, (were students sitting quietly at their desks, milling about the room or were there very few people in the room?). All these factors could contribute to different readings and should be controlled in any type of experimental design.

While aspects of PBS were implemented into the lessons, the lack of connection between designing an energy-efficient home and collecting CO_2 readings from the school was not clear. Students were engaged in science and engineering, however, and were excited about what they were doing. So, although PBS was not implemented as well as it could be, the learning of science as a dynamic subject was present.

d) Teacher D: *Fall 2012*

During the fall 2012 semester, three days of a weeklong inquiry experiment were observed in Teacher D's 5th grade class. This unit was part of a larger PBS unit on electricity and renewable energies. Prior to the unit that was observed, the students took a fieldtrip to visit a real wind turbine. They also completed a lab on wind as a source of energy and designed and experimented with sailboats using different materials and configurations for the sails. During the class immediately prior to the first observed class, students learned about circuits and connected their mini-turbines to a circuit board to understand the concepts of open and closed circuits.

During each of the three observed classes the teacher began by asking students to recall what had been done the class before. She used this reflection as an opportunity to connect that day's activity with student's prior knowledge and lead into what she referred to as a "daily question." There were two daily questions that drove instruction over the three days of this observation: "How much power does a mini-turbine produce?" and "Can a mini-turbine produce enough electricity to power Christmas lights?"

The three lessons that were observed flowed nicely into one another. The first day students learned how to connect a power meter to their mini wind turbine and record AC and DC current outputs. During this lesson they also discussed how the data they would collect could best be organized in a table and decided on the questions they would investigate the next day. They also discussed the variables that could affect the power output of the mini turbine, including, size of the blade, length of the blade, distance of the turbine from the fan, angle of the blade and the shape of the blade. As a class they decided the three variables they would like to investigate were shape, number and angle of blades.

The second day the teacher began class by asking students to think of what they might be able to power with a mini-turbine. Students came up with the ideas of a set of Christmas lights, an iPod or cell phone and the class microphone system. Students voted and the Christmas lights won. Students investigated with a box of lights to see how much power was required to light them and how they would know if their turbine was producing that much from the power meter output. The teacher then worked with groups of students to refine a researchable question in the format: "I think a mini turbine with ___ number/angle/shape of blades will produce more power than a mini turbine with ___ number/angle/shape of blades. Students were monitored and challenged to maintain consistency with the two variables they chose not to focus on while changing the variable they chose. For example, one group investigated the question: "I think a turbine with 7 blades will produce more power than one with 3 blades" while keeping the angle and shape of all the blades consistent. Students spent the remainder of class time constructing and testing their blade designs.

On the third day, after a short discussion of controlling variables and experiment set up, students continued collecting data. The teacher assigned them to write a short paragraph about their experiment by the end of class. She discussed with students that the paragraphs should include their claim, what evidence they collected to support their claim and their conclusion.

Post observation reflection: This observation provided evidence that teacher D had a firm understanding of PBS instruction. Her lessons were skillfully designed to maintain student focus on important aspects of science process and content appropriate to the developmental level of her students. No classroom management issues were observed and the majority of students were highly engaged in meaningful learning throughout the class. It also showed that teacher D was integrating renewable energies content in her class in a manner that was interesting and worthwhile for her students and connect it to her existing curriculum on electricity.

Spring 2012

Teacher D scheduled a week for the evaluation team to observe another PBS unit in her class. However, due to a family emergency and unexpected trip the observations had to be cancelled and could not be rescheduled in the remaining two weeks of the school year.

e) Teacher E

Teacher E was moved to a 4th grade position after teaching middle school for over 20 years. She felt she needed time to get comfortable with the new grade level before she could integrate PBS into her curriculum. Multiple attempts to contact her and schedule and observation were made but an observation could not be scheduled.

f) Teacher F

Teacher F was located in an outlying area approximately two hours from Toledo, OH. The evaluators planned to use the polycom system to observe her lessons. However, the teacher changed schools during the summer and the new school did not have the polycom in place. The LEADERS technology director attempted to install the camera at the new school but, due to technological issues at the school, was unsuccessful.

g) Teacher G

Teacher G told the evaluator in charge of her case study that she would be doing a PBS unit on forces and motion for the duration of the fall semester. This unit would focus on students designing the fastest sleigh possible. She felt that to teach in a manner that was true to the PBS methodology, her unit needed to follow students' ideas and it would be too unpredictable to write lesson plans or to schedule an observation more than a week in advance. She asked the observer to contact her at the beginning of every week and she might be able to predict what she would be doing on a given day of class. After several attempts to contact her with no response the effort was abandoned.

Conclusions: Observing extended lessons provided detailed information about the way in which the TLs implemented PBS. The teachers observed implemented many of the strategies developed in the Summer Institute lessons plans with increasingly positive results from fall to spring. It was difficult to schedule the observations and evaluators observed only two of the original seven both fall and spring. Two other TLs had observations in the spring, one did not schedule an observation in the fall and then had a medical emergency during in the spring, one was not observed at all due to technical difficulties (polycom would not work), and one simply did not cooperate with the evaluators as far as scheduling observations.

E. PBS Professional Development Workshops (PD)

Cohort 1 PD was divided by district—Toledo Public Schools (TPS) and Toledo Catholic Schools (TCS). TPS professional development targeted grades 3-5 and high school Environmental Science. As in previous years, TPS offered five PD workshops spaced throughout the academic year. TCS adopted a Problem Based Learning model for the entire district and incorporated PBS for science into their PD for all teachers. Cohort 2 included some teachers from TPS (3) who targeted grades 6 – 8 and teachers from Monroe County School District. Monroe offered five PD sessions to two general groups—elementary teachers and high school teachers.

At the conclusion of the first and last PD sessions, district teachers were given a feedback form that asked them to rate their satisfaction with various aspects of the PD (TCS only completed the final PD evaluation). Scoring on the PD feedback form ranked the district teachers' level of agreement using a four point scale ranging from "not at all" (1) to "to a great extent" (4). Modes and medians were determined and written comments provided by the district teachers were included in a formative evaluation report provided to project leadership. A summary of the feedback is presented in Table 6 by group. Because there was no change between rankings between the first and last PD sessions, only the final feedback rankings are shown.

To augment information gathered from the feedback forms, each group of district teachers from Cohort 2 PDs participated in a focus group interview at the conclusion of their last PD session. The following summary of findings is broken into TPS and Monroe.

TPS Cohort 2: The teachers appreciated the opportunity to participate in the PDs and felt they were well planned. The teachers learned new teaching strategies, science content, and indicated there was plenty of time spent on lesson planning. Their definition of PBS focused on student-centered and led instruction. They felt PBS allowed students to participate in learning—sometimes students offer insight that the teacher might miss. Their intention to implement PBS seemed to focus more on incorporating activities or strategies into what they are already doing. Several teachers mentioned using a graffiti map that allows students to share their learning with one another. The emphasis on activity is typical of teachers who are new to PBS (these TLs are in their first year of providing PD). The teachers were made aware of many local resources and they particularly liked the Google group that allowed them to interact with one another remotely. Finally, they felt the TLs could recruit more teachers if they went to the schools or a district meeting and made a presentation.

Monroe: Six teachers were interviewed. Only two teachers attended all five PDs and the others said they missed some because they had not been given notice far enough in advance to plan for them. The teachers felt the format of the sessions to be suitable although they admitted it took a few sessions to get used to the structure and the "philosophical switch" PBS requires. One teacher noted that after exposure to this philosophy of teaching science she felt as though she had "ruined all those other kids." The teachers said the new techniques they learned, while different, make perfect sense, are relevant to their teaching, and are logical. Another teacher said that PBS has changed the way she approaches her content by allowing her to understand that the students can learn without her, even when she is teaching in a more hands-off way. However, one teacher said that project-based learning forced her to think about the resources that the students need, which posed a challenge for her.

The teachers provided adequate definitions of what PBS entails. Teachers appreciated that the PDs included discussions about how to set up their classrooms and manage cooperative learning. While enthusiastic about implementing PBS, teachers indicated a few concerns—needing more time to prepare, wondering how PBS might affect student test scores (although students may be more engaged and well-behaved because they think they are playing, they may have trouble linking what they learn back to course objectives). Another teacher expressed concern regarding where PBS fits into the Common Core. This teacher said that implementing PBS in small steps would be most appropriate. Another teacher brought up the issue of cost—one project might cost up to $70.

When asked about obstacles that might prevent PBS from being implemented, some teachers said that the fact that they did not yet have a framework to present the curriculum to administrators would result in a decline in necessary financial support. The teachers also said they need books, which would help them gain ideas for projects that are appropriate to the content level they are teaching. On the other hand, the teachers mentioned many resources they have become aware of as a result of participation in the PD.

To improve upon the PDs, the teachers suggested that including teacher enactment with students in future sessions, perhaps in the form of short videos, would help. The teachers also wanted to see “the end product” that shows “the model of what I am supposed to do,” thereby demonstrating that the goals are achievable. The teachers who have TLs in their buildings said that it was helpful for the TL to have “an open invitation” for teachers to communicate with and observe that person.

Table 6: PD Feedback Summary

	Spring 2013		
Group	Mode	Median	Unusual items
Cohort 1			
TCS all grades	4	3	
TPS Elementary	4	4	
TPS high school	3	3	Scored a mode/median of “2” for *I would recommend this session to other teachers.* Note: there were no comments provided by attendees to support this ranking.
Cohort 2			
TPS	4	4	
Monroe	4	4	

F. Science Café

Science Café continued to be used as the main “outside the classroom” communication hub for the Summer Institute courses as well as a means to share during the academic year. Use and usefulness of Science Café was gauged using the SNA detailed in Section G below. In general, TL use of Science Café as a resource for advice, information, material and instructional resources and problem solving increased over time.

G. Professional Networking

Cohort 2 TLs completed the professional networking survey in May 2012 (reported in 2011-12 Annual Evaluation Report) and again in December 2012. Cohort 1 will complete the survey June 2013 (no new results at this time). The survey includes qualifiers or level of quality beyond just frequency of interaction. For each of the resources, TLs were asked to rate frequency of interaction with regards to their science teaching, as they prepared and delivered PBS professional development, and in their role as a coach for their science educator peers. Within each of those areas, TLs indicated frequency of interaction with the resource with regards to science content, PBS pedagogy, and to show connections to the local economy. Comparison of pre and post Institute participation illustrates resource utilization resulting from participation in LEADERS.

The survey classified the way in which TLs might use resources using the following categories:

Advice: An opinion or a recommendation about something you know/use or for future purposes (What do you think of the windmill kit? Do you think this content is appropriate for my students?)
Influence: Influence over policy or procedural changes/social changes/sustainability of knowledge (e.g. Help establishing a safety policy in the school science lab or assistance in making PBS professional development a common practice)
Information: Knowledge concerning a particular situation/fact/idea (Where can I find the sample lesson plans)
Interpretation/Evaluation of Information: To make better sense of something or assist in application of theory to practice (How might this experiment relate to my unit on kinetic energy?)
Material resources: Teaching supplies/teaching materials/curriculum material/classroom supplies
Problem solving: Reaching out for expertise on a problem you cannot resolve alone (How do I motivate a particular teacher?

UCINET software was used to analyze the data. The thickness of line connecting to resources reflects the number of teachers within the group that used resources based on the categories listed above. As can be seen in Figure 1, prior to participation in the Institute, TLs in Cohort 2 got the majority of their advice from other teachers in their schools. After the SI, TLs looked to their new colleagues for advice (other TLs) indicating that a professional learning community had formed as a result of the shared summer experience. TLs also made use of LEADERS resources such as the Network Coach. Post SI connections were also made to the University group resources that did not exist prior. The use of professional education journals saw a dramatic decrease, and Internet was reduced, splitting its share with the new Science Café web resource.

Figure 1: Advice-Seeking Pre-Summer LEADERS Institute

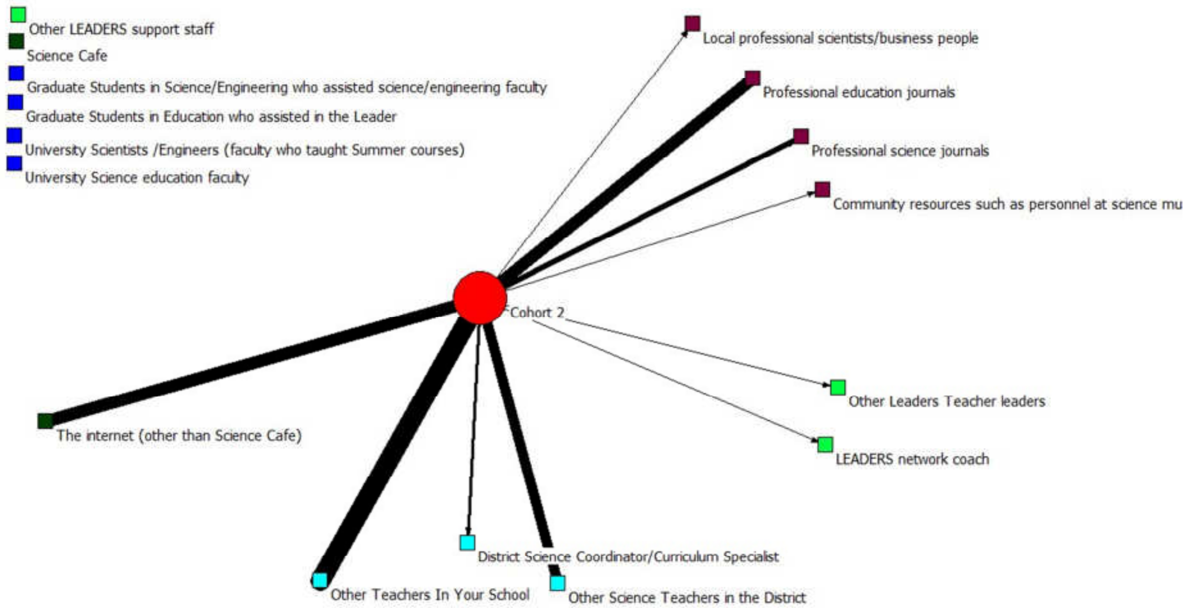


Figure 2: Advice-Seeking Post-Summer LEADERS Institute

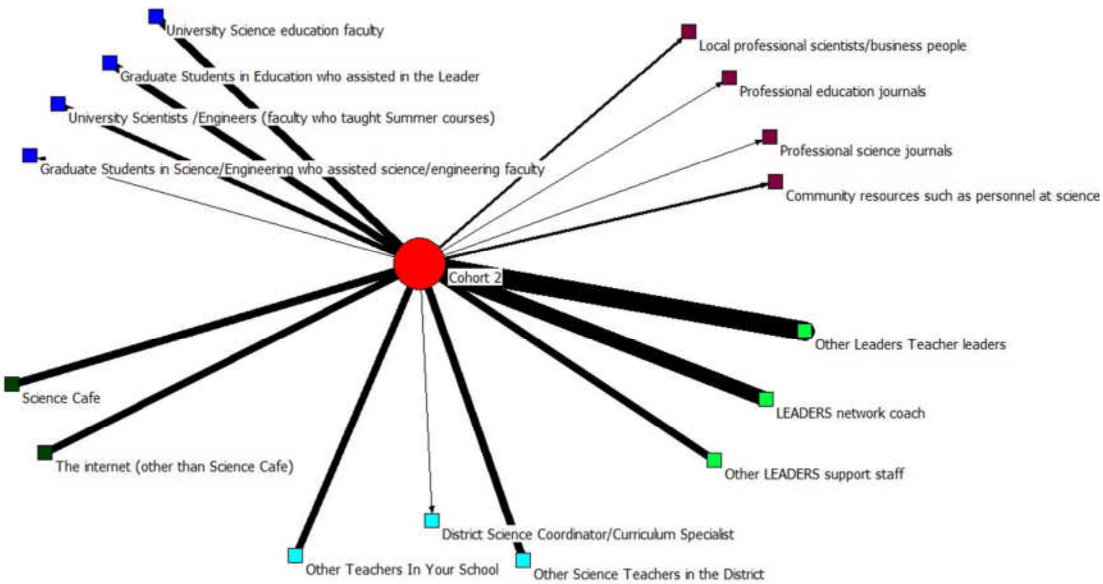
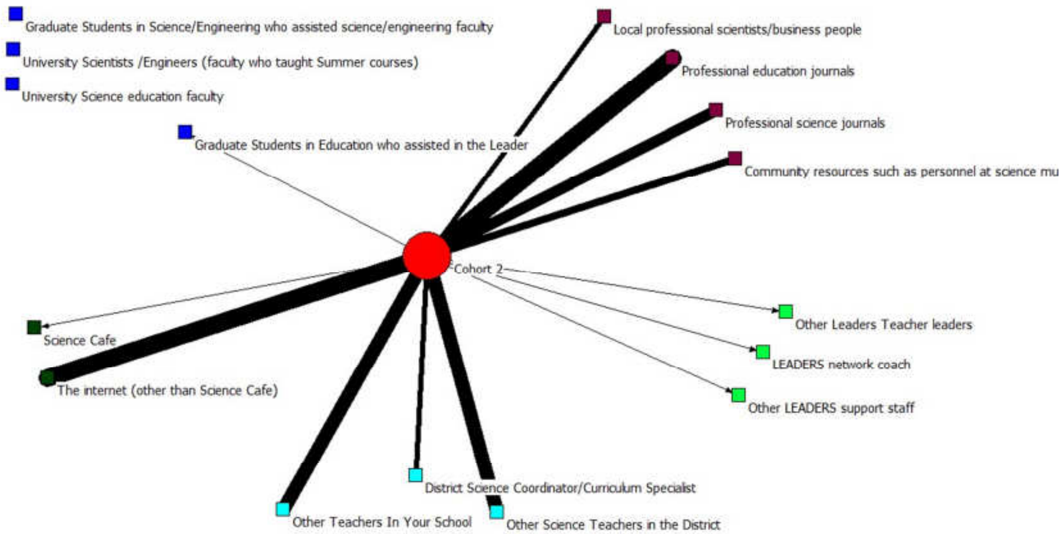
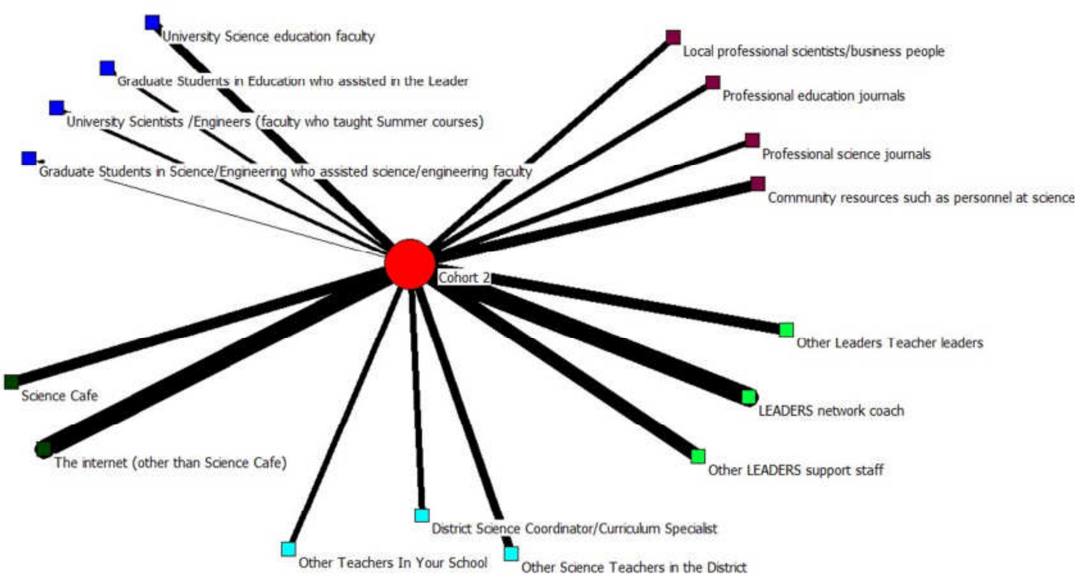


Figure 3: Information seeking Pre-Summer LEADERS Institute



Pre-SI teachers obtained information from the internet, other teachers and science teachers in their schools, and professional education journals to great extent. Little connection existed between the university group and LEADERS group resources (blue boxes, top right of web).

Figure 4: Information seeking Post-Summer Institute



However, after participation in LEADERS, interaction with university groups and LEADERS support increased. As with "advice," utilization of other teachers within the teacher participant schools decreased along with significant decrease in the usage of professional education journals.

There is also a shift in resource use to influence instruction from predominantly school oriented and general public resources to other TLs and LEADERS resources. New connections were created between the participants and the rest of the LEADERS group and university group as well. The internet as a resource has lost half of its influence to the new Science Café web resource. Most dramatic is the decreased influence from the community group.

Figure 5: Influence on Science Instruction Pre-Summer LEADERS institute

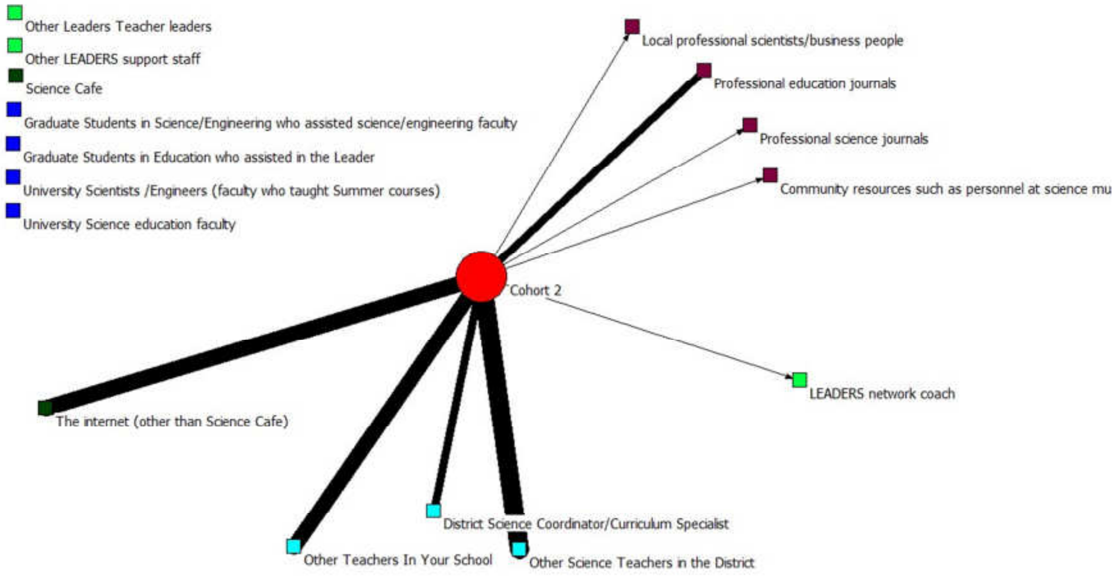
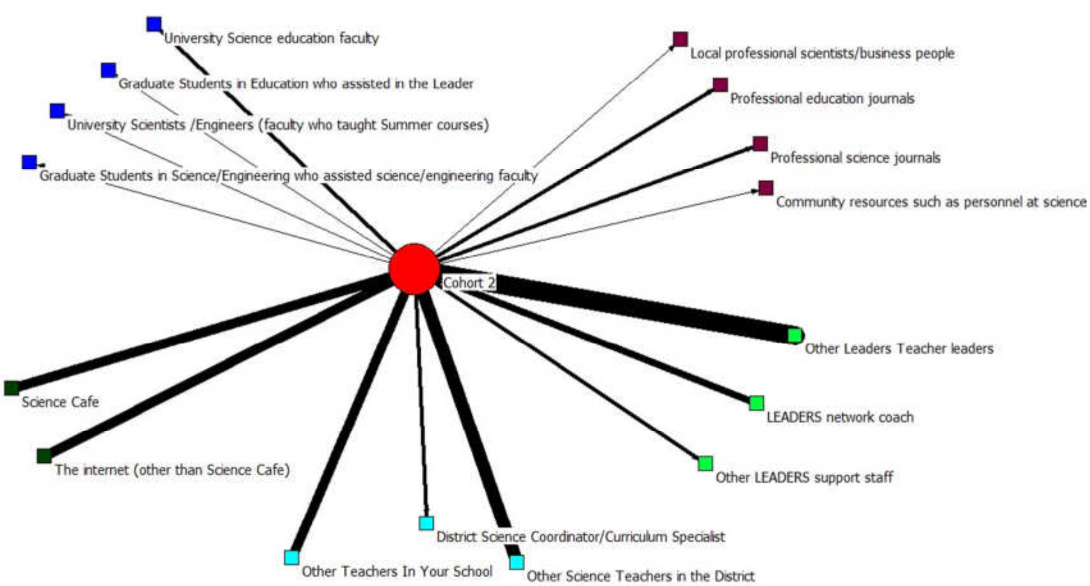


Figure 6: Influence on Science Instruction Post-Summer LEADERS Institute



The next two figures, related to interpretation of science materials, show an interesting change in that prior to the SI, TLs had two major resources—other teachers at their school and the Internet. Post SI shows a much more diverse array of resources including large changes in the utilization of the LEADERS group and university group, along with the Science Café. The decrease in teachers within the participant's schools is minor and the changes in the community group also small.

Figure 7: Interpretation of Science Material Pre-Summer LEADERS institute

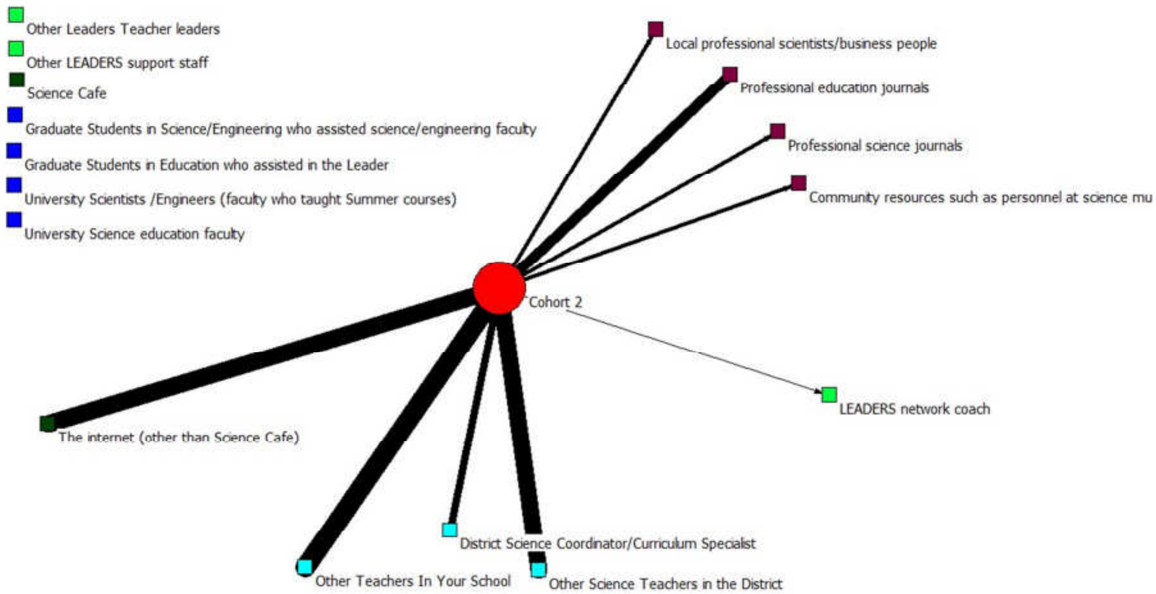


Figure 8: Interpretation of Science Material Post-Summer LEADERS institute

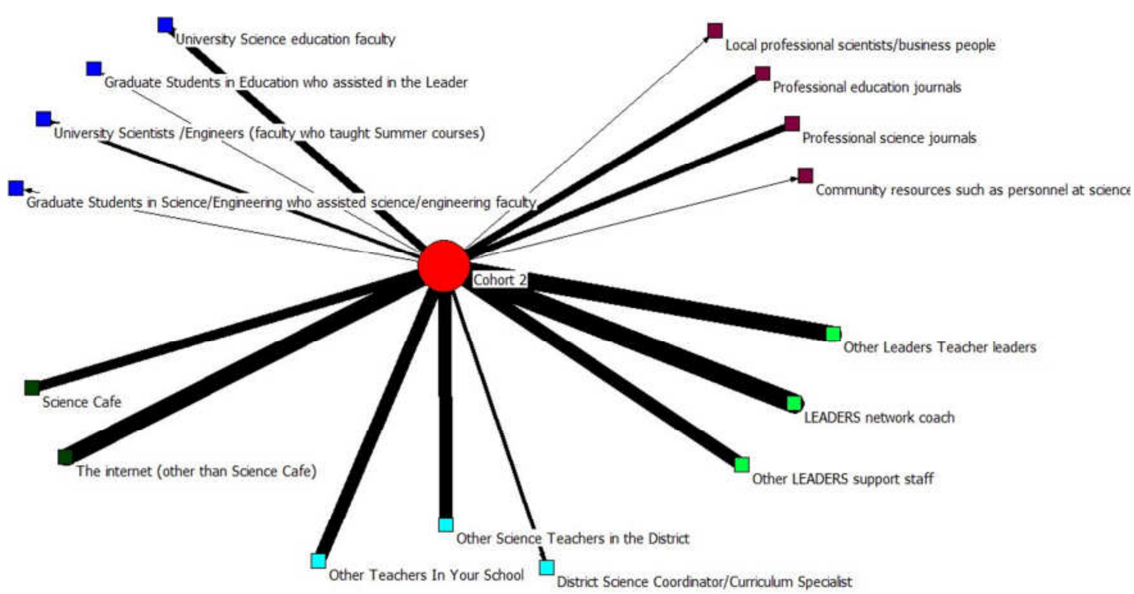
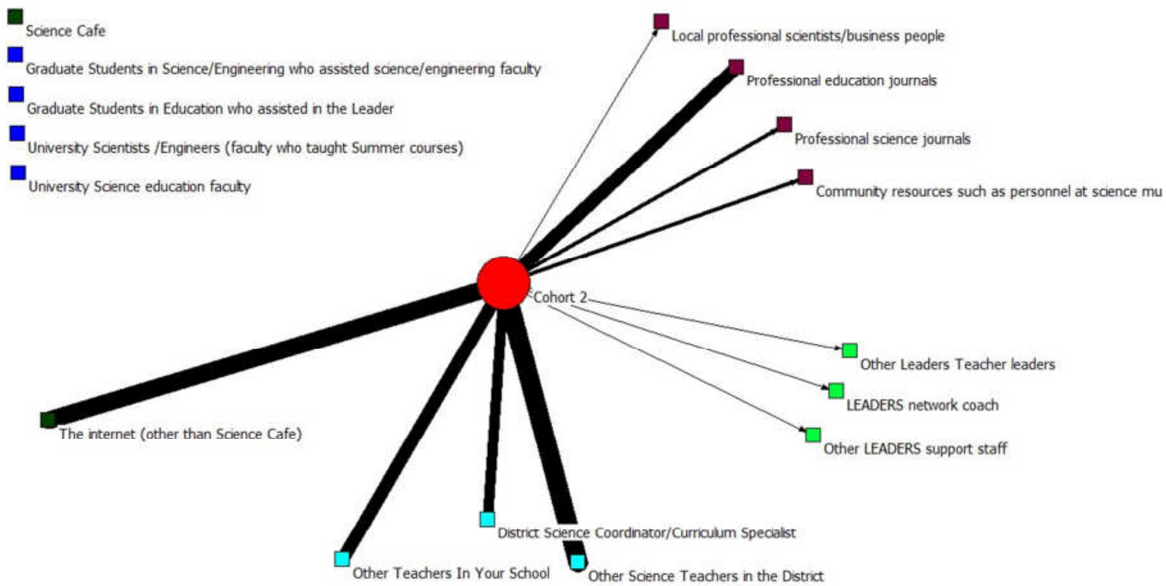
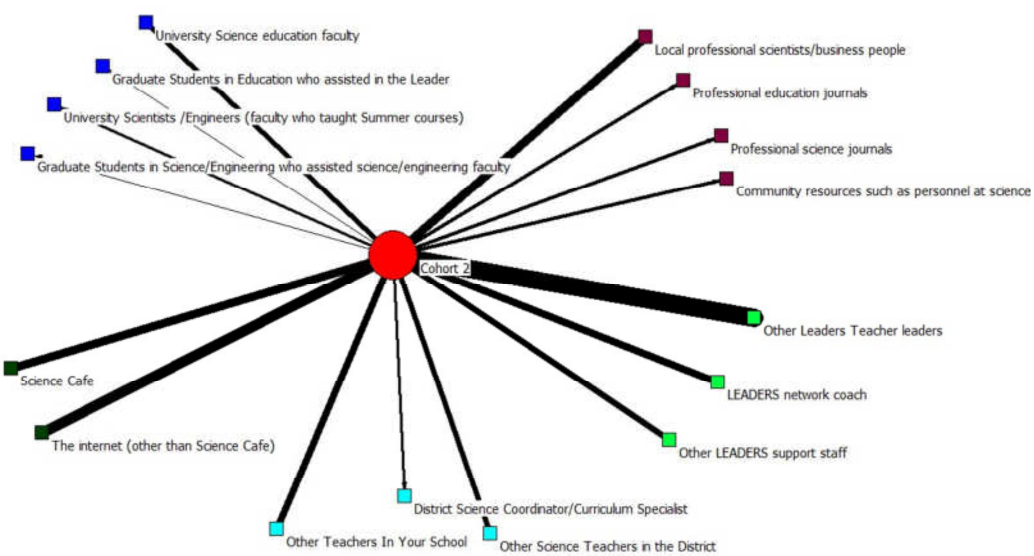


Figure 9: Material Resources Pre-Summer Institute



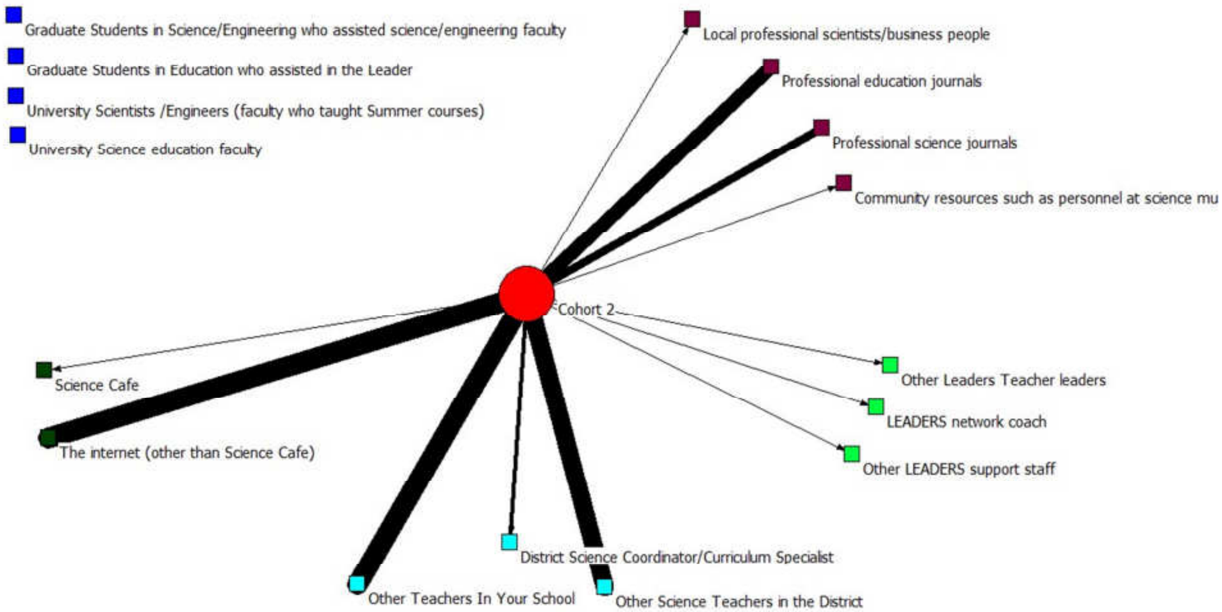
As with influence, pre SI use of material resources was overwhelming located in TL home schools, with the internet and professional journals following closely. Post SI shows the teacher switched reliance to other TLs for the greatest amount of their material resources and substantial connections to the other LEADERS group resources along with the university group now exist. The participant's school group has seen a decrease in is importance to material resources. The internet splits its contribution with the Science Café. The use of professional education journals falls yet there is a marked increase in local professional scientists/business people.

Figure 10: Material Resources Post-Summer Institute



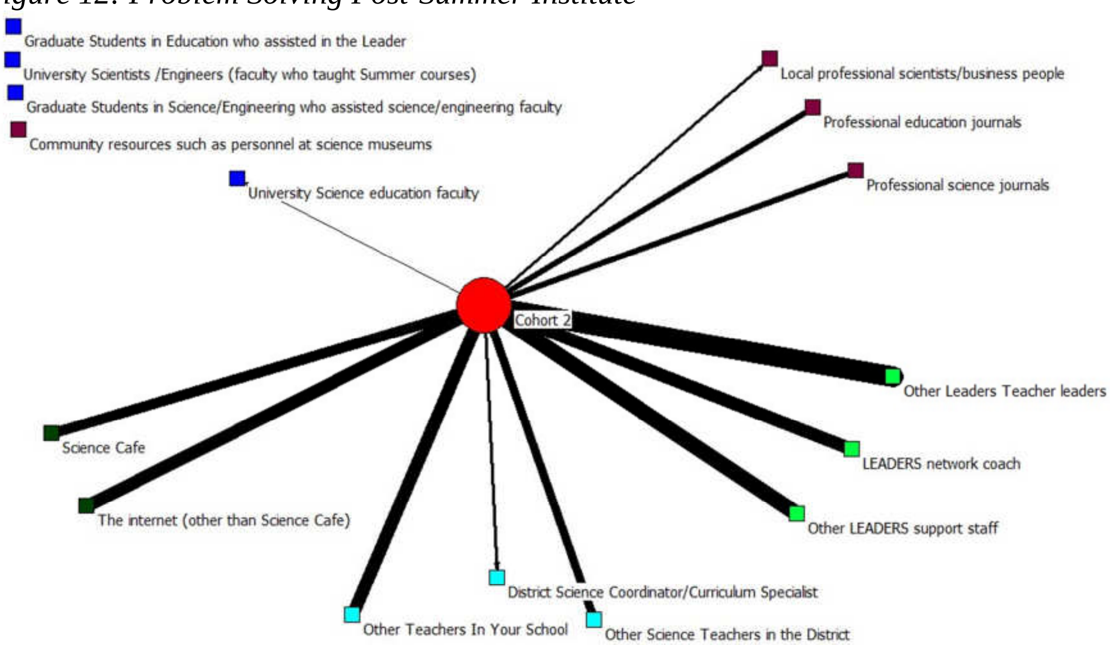
The use of resources for problem solving follows similar patterns with the expansion of resources used as a result of LEADERS participation. It is interesting that although university scientists were not considered to be a resource for problem solving, after the SI some use of science faculty to assist with problem solving now exists.

Figure 11: Problem Solving Pre-Summer LEADERS institute



Prior to participation in LEADERS, problem solving among LEADERS participants focused around other teachers in their schools, the internet and professional education journals. No connections existed to the University group and limited connections to LEADERS group.

Figure 12: Problem Solving Post-Summer Institute



Problem solving post SI is overwhelmingly focused on the LEADERS group; the internet splits its share with the new Science Café. A decrease is seen in the usage of teachers within the participants' schools, only a single teacher claimed using a University science educator, and the community group has seen a decrease in the journals used and community resources within that provides no problem solving.

Overall, participation in LEADERS has expanded the source of support that TLs consult for various aspects of their teaching and PD. While TLs continue to use the "go to" resources of pre SI, they now go beyond the typical resources to include university resources and those created for the project. The frequent use of other TLs in every post SI sociogram is strong evidence that a cohesive professional learning community has developed in only six months.

H. Summer Institute

Once again the evaluation of the LEADERS Summer Institute consisted of a pretest/posttest comparison of grades for coursework, an exit survey for each course based upon Chickering and Gamson's 7 Principles for Good Practice (1987), and a focus group interview to explore the summer experience in greater depth.

1. Content Knowledge

Cohort 1 took Earth Systems Science, Master's Project/Thesis, Alternative Energy, and Leadership III (Social Foundations and Theory). Cohort 2 took Earth Systems Science, Alternative Energy, Project-Based Science, and Leadership I (Educational Psychology). Pretest/posttest scores on content were compared using a paired t test, effect size, calculation of Cohen's U which predicts which percentile someone who fell in the 50th percentile would end up on the posttest based upon this group's performance. Data were not collected for the Project Based Science course (content knowledge was gathered from observations and examination of lesson plans) or Leadership I (data not provided by instructor). Table 7 provides the results of the analyses.

Table 7: Summer Institute Content Knowledge

Cohort	Pretest mean	Posttest mean	t	P	Effect size	Cohen's U
Earth Systems						
1 (n = 9)	4.75	5.71	3.71	0.003*	1.62	95th
2 (n = 14)	4.98	5.28	1.77	0.05	0.74	77th
Alternative Energy						
1(n = 9)	6.7	13.1	8.55	<0.001*	2.44	99th
2 (n = 14)	5.43	13.35	7.10	<0.001*	5.67	99th
Leadership III						
1 (n = 12)	15.6	34.24	6.04	<0.001*	1.83	97th

*Denotes statistically significant gains

Even with small sample sizes, all pretest/posttest comparisons showed statistically significant gains except Cohort 2 for Earth Systems. Because a small sample size tends to mask true gains, it is possible that Cohort 2, if it were a larger sample, would have shown statistically significant gains as well. All of the effect sizes were medium to large and in most cases a TL who scored in the 50th percentile on the pretest would rank at or above the 95th percentile on the posttest.

Conclusion: TLs realized substantial gains in content knowledge over the course of the Summer Institute.

2. Participant Reactions

The TLs were also asked to complete a course feedback form that asked them to rate the following (5 point scale from poor (1) to very good (5)):

- The clarity with which the course objectives were communicated.
- The clarity with which specific class assignments were communicated.
- The timeliness with which papers, tests, and written assignments were graded and returned.
- The degree to which the types of instructional techniques that were used to teach the class (e.g., lectures, demonstrations, online discussions, case studies, etc.) helped you gain a better understanding of the class material.
- The timeliness with which your instructor responded to your communications.
- The extent to which you felt you were part of the class and belonged.
- Your access to effective communication with the instructor.
- The level to which the course and its activities were organized and planned.
- Your access to effective communication with other members of the class.
- The extent to which the course design encouraged active participation.
- The opportunity to share and/or discuss your work with other students in the class.

Overall, courses scored consistently in the good to very good range. Table 8 shows the percent of responses in each of the categories for the five courses evaluated (Earth Systems, Alternative Energy, Leadership I, Leadership III, and Project Based Science.

During the 2012-13 academic year, scientists worked with a science educator to explore effective teaching strategies to incorporate into the 2013 SI. Scientists were interviewed prior to the SI and will be interviewed again post SI to gain an understanding of the effects working with the science educator has had on the scientists' teaching—both during the SI and in the university classroom.

Table 8: Participant feedback on SI courses

Course	Very Poor	Poor	Average	Good	Very Good
Earth Systems	1%	16%	24%	34%	25%
Alternative Energy	1%	9%	16%	34%	40%
Leadership I	0%	0%	3%	27%	70%
Leadership III	1%	0%	10%	30%	59%
Project Based Science	0%	0%	1%	10%	89%

3. 2012 Summer Institute Cohort 1 Focus Group Interview

Cohort 1 met with the evaluator for a focus group interview on July 20, 2012. Many of the questions asked were repeated from Year 2 to determine whether opinions and understanding had changed. The TLs felt that this Institute offered the best schedule of the three they had attended. They particularly liked that all of the classes would be completed by the end of the

Institute and found the PD planning periods with Cohort 2 to be valuable. They would have liked equivalent time allotted each summer to work on PD plans.

This summer tied everything together for the TLs. They felt the social foundations course to be especially beneficial and suggested that it be offered to Cohort 2 during Year 2 rather than Year 3 because it provides a needed foundation for the assessment course offered during the second Institute (switch assessment with social foundations). As far as content courses modeling PBS, they felt the instructors tried but fell short in some ways. For example, the labs in Alternative Energy course were prefaced with a detailed description of what would happen during the experiment so that the TLs did not experience the lab first hand even though they conducted the experiments (they already knew what would happen and why). Also, while many noted that the Earth Science course utilized the jigsaw method to bring everyone together, some felt it was overdone and one TL noted that not everyone learns that way. On the positive side, they found the Energy instructor to be quite flexible and his teaching assistant was given a lot of time to teach and explain. They were satisfied that they were leaving the Earth Science course with a full lesson to implement and they wished every course had been like that.

The TLs were asked if the Institute contributed to their understanding of how renewable energies affect the Great Lakes region and its economic development. The TLs saw a problem tying renewable energy science with economic development because this industry has not really panned out. Global economic issues have affected the local economy including the production, for example, of solar panels. Some TLs felt linking science to local issues did not necessarily improve science learning while others noted that students seemed more interested when inquiry based learning was coupled with local applications.

The TLs used Science Café as a resource for courses as required and did acknowledge that they would use it as a resource more frequently if it were easier to navigate. For example, they found the organization to be counter-intuitive for use beyond the time when they are taking a course because it is organized by day in which a topic was discussed. One TL wanted to review a PowerPoint presentation on assessment but could not remember the date the instructor presented it. While there is a search engine, TLs felt it was deliberate or slow. Many times they would rather just search on the internet than log into Science Café and run a search. Logging in takes time as well, particularly when doing so off-campus. They did appreciate the resources Science Café has and hoped there might eventually be an easier way to obtain them such as through the LEADERS website (note: this interview took place Summer 2012 and the SNA analysis in Section G was performed in December 2012).

The TLs also discussed their understanding of PBS. Most felt that their understanding of PBS changed dramatically between Years 1 and 2 but not much between Years 2 and 3. They felt confident with their responsibilities for Year 3 and noted that their confidence has increased significantly over the end of the first Summer Institute. All TLs except one felt that there was a great deal of district support for them as TLs (one noted that the principal of the TL's school was not happy about the release time required to fulfill TL responsibilities). In general, the TLs found that they are being recognized as leaders in their districts. For example, principals from other schools are contacting them to provide PD to their schools and district teachers contact them as a science resource. Cohort 1 recommended that Cohort 2 not only practice PBS in their classrooms but bring artifacts from the classroom to the PDs to share with the district teachers as examples.

The TLs were asked how well they thought the project has done as far as meeting its two major goals:

A. Develop[ing] a cadre of effective teacher leaders who transform science education by linking science content with emerging science-based industries in Great Lakes Region.
B. Transform[ing] existing K-12 science courses to rigorous and relevant science courses through PBS.

The TLs agreed that everyone is doing a “fabulous job merging PBS with content” but that it is hard to force the content to tie in with local economy. As far as Goal B, “that’s where it really shows” “and that “rigor is really there”. TLs noticed that their own students are going to higher levels of exploration into science than previously.

Finally, the TLs were asked to provide evidence of the effect they have had on the district teachers who have attended the PD. They mentioned that teachers were eager to know what the topic for the PD was going to be that day. They would report back at the next PD that they incorporated the ideas into their courses and detailed how well it went. One district teacher had her students participate in the science fair this year for the first time and some teachers showed TLs what they did with their own children at home as well as with their students.

Conclusions/Recommendations: The third Summer Institute provided a reasonable schedule that included two weeks of PD planning that the TLs found to be helpful. The courses continued to be challenging and the content was conceived as useful to them in their role as both a teacher and a TL. Science Café is an appreciated resource but cumbersome. The information it stores should be considered for a more public website that can be accessed by the TLs and their district teachers. If possible, Assessment should be offered Year 3 and Social Foundations Year 2 for Cohort 2. The TLs left their final Summer Institute feeling confident in their abilities to serve as TLs and provided concrete examples of the positive effects of the PD they delivered.

4. 2012 Summer Institute Cohort 2 Focus Group Interview

Members of Cohort 2 met with the evaluator on August 1, 2012 to share their experiences during the Summer Institute. The discussion began with questions about recruiting for the program and the application process. In general, the TLs heard about the program through an email from someone at the administration level in their district. The information was brief but enough to garner some interest. Some attended a meeting where LEADERS PIs presented more information. Overall, the most common reason for applying to the program was to obtain a Master’s degree. One TL indicated the renewable energies content was appealing.

The TLs felt the application process for the program to be clear and easy to follow. They felt the interviews allowed them to go into greater detail as to their qualifications and the preparation for the interviews caused them to reflect on their teaching.

As far as understanding what would be expected of them as TLs, the participants agreed that they did not have a clear idea until about a week ago. However, they had a general idea of what was to be expected of them and were not surprised nor felt misled (as some in Cohort 1 indicated during their first summer). Most felt that the events of the SI might have made more sense if they had received more detailed information at the onset as to what they would be doing during the academic year. One noted that the project staff indicated that the details were purposely introduced near the end of the Institute so as not to overwhelm the TLs. The TLs did not think this information would overwhelm them but would rather allow them to put everything in perspective.

The TLs liked the six week format and were grateful that content courses would not continue into the academic year. They had a lengthy discussion about some of the courses; however, that information will not be reported here as the TLs were directed to the course evaluations as the appropriate place to make comments and recommendations concerning individual courses. They did mention that the courses did a good job of modeling PBS.

All agreed that they had a clear idea of what their next steps as a TL will be, they were prepared to carry out those responsibilities, and they were confident they can implement PBS in their classrooms.

Conclusions: Many of the issues experienced during the first Summer Institute have been corrected and Cohort 2's first SI ran smoothly. The revised recruiting process has proven to be effective.

III. District Science Teachers

Response to our annual surveys for district teachers from control and treatment schools was dismally low. Of the potential 500+ teachers, only 23 responded in spite of repeated requests for participation. Upon recommendation from district teachers in 2012, the log-in process was changed from teachers identifying specific schools at which they taught to allowing teachers to select from a group (district and treatment/control). This change, which was to make teachers more anonymous, did not improve response rates as shown in Table 9.

Table 9: Response rates of district teachers

District	Total	Responded		
		2010	2011	2013
TPS	212	46	47	0
TCS	194	85	74	17
Monroe	185	n/a	n/a	6

District teacher data historically consisted of a test of renewable energy content, the STEBI, and the STIPS. Because the response rate was a fraction of the sample, analysis of data collected in fall 2012 was not done because it would not represent the population. Additionally, unless Monroe District can provide more support in gathering a representative sample of teachers from the control and treatment schools, these instruments will not be administered during the final year of the project as the data does not represent the population nor does it add to findings.

As a substitute to surveys, classroom observations of district teachers who attended the PD sessions were proposed. Teachers were asked to volunteer to be observed (similar to the case studies for TLs) and were provided with gift cards as compensation for their time. Unfortunately, only four teachers volunteered from all who attended PD sessions. Those observations were conducted in May 2013 and will be included in the next reporting period.

On a positive note, the Toledo Catholic School district (Cohort 1), as a result of involvement with LEADERS, has adopted a problem based learning model for the entire Diocese so inquiry based learning takes place not only in the science classroom but with every subject across the district.

IV. Student Data

Students in the district treatment and control schools are assessed on three measures: (1) Ohio Achievement Test in Science for public schools in Ohio; (2) Student knowledge of renewable energy content and area commercial activity for students in grades 6 and 8; and (3)

Student attitudes towards science and interest in pursuing a science-related career. The content test follows a pretest/posttest design (fall and spring). Because the posttest data on the content test and all student attitude data are collected in May, findings from the previous year are reported here (2011-12) and 2012-13 results will be reported next year. Results for the Ohio Achievement Test are for the previous year as well as the state has yet to release 2012-13 results.

A. Ohio Achievement Test in Science

Ohio Achievement Test in science for grades 5, 8 and high school was collected from treatment and control schools in TPS (TCS does not take the test and Monroe Schools are in Michigan). Passing rates for 2012 were compared between treatment and control schools per grade Chi Square test of Independence was performed and results are presented in Table 10. As in Years 1 – 3, *the Chi Square test yielded no statistically significant differences in passing rates between the two groups of students ($\chi2 = 1.58$, 2 df).*

Table 10: 2011 TPS Ohio Achievement Test in Science Passing Rates

	Total Students	Number Passing	% Passing
Treatment Schools			
Total 5th grade	641	303	0. 7
Total 8th grade	756	341	0.45
Total HS	1448	980	0.68
Control Schools			
Total 5th grade	494	275	0.56
Total 8th grade	762	344	0.45
Total HS	1473	964	0.65

B. Student Attitudes Towards Science

Student interest in science and science-related careers were measured using the Student Attitudes towards Science survey developed by Mentzer for the NSF Gk-12 project, *Graduate Fellows in High School STEM Education: An Environmental Science Learning Community at the Land-Lake Ecosystem Interface* and adapted from the “Conceptions/Nature of Science” survey used by the NSF DUE project, *Creation of an Interdisciplinary Earth Materials Testing Laboratory to Enhance Undergraduate Science Education, University of Wisconsin - Stevens Point*. The survey also incorporates Klopher’s (1971) categories of affective behaviors in science education that cross behaviors with phenomena to allow us to discover to what extent students internalized positive aspects of science and whether teachers who implement PBS can affect this change. Internalization occurs when a value or phenomenon becomes a part of the individual’s identity. The survey specifically targeted favorable attitudes towards science and scientists, enjoyment of science, the development of interests in science and science-related activities, and the development of an interest in pursuing a science-related career. Grade-level adaptations of the survey were made for grades 3-4 and 5-6. The survey as designed was given to grades 7-9.

Because the data is from the spring 2012 collection period, only findings from TPS and TCS (Cohort 1) are reported.

The data analysis was conducted with standardized Rasch Scores to determine whether the treatment group would be different from the control group as a result of exposure to PBS. The group difference of the treatment and control groups using the mean scores was examined with independent t-test statistics. The analytical results were conducted on three grade levels, grades 7-9, grades 5-6, and grades 2-3 and are discussed below:

7–9 Grade Levels

Prior analysis of the baseline (fall 2011) data showed that the treatment and control groups were equivalent (t- one tailed = 1.65) on both the value they place on science and interest in science. Results of the 2012 comparison are in Table 11. There was no statistically significant difference between the treatment and control school students on either of the scales.

Table 11: Grade 7 – 9 T-test Comparison of Treatment and Control Groups (2012)

Items	Trtmt	Value	Interest	Control	Value	Interest
No of items		6	10	No of items	6	10
No of persons		1536	1536	No of persons	1834	1834
Mean		20.32	18.71	Mean	20.15	18.96
Standard dev.		8.10	6.78	Standard dev.	7.58	6.75
Cronbach test		.51	.64	Cronbach test	.57	.67
Group difference on **value of science**, t (df = 3368) = 0.005; P = .999 ; (F = 4.779; P =.02) equal variance assumed						
T/G*C/G difference on **personal interest in science**, t (df = 3368) = -0.01; P = .0.992 (F= 1.064; P = .302)- equal variance assumed						

5-6 Grade Levels

The 2011 student data showed treatment and control groups to be equivalent on both scales. 2012 showed no differences in groups on either scale at the time of posttesting as displayed in Table 12.

Table 12: Grades 5 - 6 Comparison of Treatment and Control Groups (2012)

Items	T/G	Student value in science	Student view in science	C/G	Student value in science	Student view in science
No of items		5	9	No of items	6	10
No of persons		1006	1006	No of persons	1063	1063
Mean		14.09	12.23	Mean	13.66	12.26
Standard dev.		3.43	2.68	Standard dev.	3.04	2.69

T/G*C/G between group difference on **value of science**, t (2067) =.0.08 ; P = 0.63
T/G*C/G between group difference on **personal interest in science**, t (2067) = -0.008; P = .99

3-4 Grade Levels
The survey for grades 3 and 4 was not broken into two scales as the number of items was low (10) and a factor analysis did not indicate multiple scales. Student attitude about science in general is the construct examined at these grades. There was no statistically significant result between the treatment and control group students.

Table 13: Grades 3 -4 Comparison of Student Attitude About Science

Items	Treatment	Control
No of persons	1248	1109
Mean	8.03	8.33
Standard dev.	2.86	3.04

t (df = 2355) = -0.02; P = .99

Conclusion: No differences existed between treatment and control school students on the measures of student value of science and student personal view of science. It cannot be concluded that teacher participation in PDs has a positive or negative effect on this construct.

C. Student Knowledge of Renewable Energy Science

Fall 2011 6^{th} and 8^{th} grade students were given a short content test in renewable energy developed by project faculty. TLs reviewed the tests to verify content validity. The students retook the test in May 2012 but the results of that administration were not reported in the Year 3 report. Results are discussed here and 2012-13 results will be included in next year's report. Group equivalency was established on the pretest. There were 20 possible points on the test. On the pretest, TPS students scored a mean of 6.45 (treatment) and 6.33 (control) at the 6^{th} grade level. The standard deviations for both groups were approximately 2. For the 8^{th} grade TPS means scores were 7.21 (treatment) and 7.23 (control). TCS students had means of 8.88 (6^{th} treatment), 8.77 (6^{th} control), 10.17 (8^{th} treatment), and 10.54 (8^{th} control). T test comparisons resulted in $p > 0.05$ within each district.

The May 2012 posttest results were compared in a similar fashion. Results are provided in Tables 14 and 15. There were no statistically significant differences in posttest scores for TCS students at both sixth and eighth grade. TPS had similar results except for 8^{th} grade where the control group actually scored statistically significantly higher than the treatment schools. Based upon this year as well as previous years' results, it is not expected that teacher participation in the LEADERS PD has a statistically significant effect on student performance on this test due to several factors including the short amount of time teachers have been involved in the project, an uncertainty as to the degree to which teachers are implementing PBS into their science instruction, the high level of student transience, and confounding variables such as other professional development programs that could be occurring at the control schools or control teacher participation in continuing education.

Table 14: TCS Content Test Comparison

TCS 6th grade	Treatment	Control	TCS 8th grade	Treatment	Control
Mean	9.80	9.24	Mean	10.07	10.49
Std. dev.	2.90	3.02	Std. dev.	3.20	3.47
Observation	214	177	Observation	216	138
Std. error of mean	.20	.22	Std. error of mean	.22	.29
Hypothesized Mean Difference	0		Hypothesized Mean Difference	0	
DF	389		DF	352	
t	1.86		t	-1.17	
P(T<=t) two- tail	.06		P(T<=t) two-tail	.22	
Mean difference	.56			-.42	
Equal variance assumed					

Table 15: TPS Content Test Comparison

TPS 6th grade	Treatment	Control	TPS 8th grade	Treatment	Control
Mean	6.44	6.57	Mean	6.83	7.47
Std.dev.	2.75	2.99	Std. dev.	3.35	3.47
Observation	322	388	Observation	454	224
Std. error of mean	.15	.15	Std error of mean	1.6	.23
Hypothesized Mean Difference	0		Hypothesized Mean Difference	0	
DF	708		DF	676	
t	-.605		t	-2.31	
P(T<=t) two- tail	.54		P(T<=t) two-tail	.02	
Mean difference	-.13		t-test mean diff.	-.64	
Equal variance assumed					

V. The Partnership

In April 2013 a focus group interview was conducted with the business/industry partners of the MSP. The purpose was to gain a clearer understanding of the role these organizations played in the LEADERS project and in particular, in learning ways in which the various partners of the program have interacted. Several organizations offered that they provided equipment for use by teachers to conduct sampling, to allow students to explore, and to conduct experiments. Equipment included solar panels, parts for wind turbines, and components of bio-refineries. Several of the business partners also spoke with the teachers and students both formally and informally as well as provided tours of their facilities.

When asked if sponsoring field trips proved difficult, the partners felt it was not so much from their perspective but rather the issue seemed to focus on scheduling the buses and more importantly the schools having the funds to pay for the busses. For example, the recycling operation in Bowling Green, Ohio seemed farther than most schools were willing or could afford to go. Financial issues also persisted in getting students to the Imagination Station within the Toledo city limits. These problems have been circumvented to some extent on individual cases where grants have been written. The Soil and Water Conservations District in NW Ohio received a grant that helped provide transportation to see things firsthand. Another interesting opportunity for students arose when a solar company, via a grant underwritten by a major player in the solar industry, installed solar panels in a school and the school was able to navigate data acquisition and study how solar power affected energy consumption allowing the students to have an active role in the process.

One suggestion provided by a partner to overcome the financial burden of field trips was using technology for these tours. Instead of having the kids go to the site, this partner suggested a virtual tour. The partners agreed that it wouldn't be quite the same but would be better than nothing at all. Another solution offered was to bring the technology to the classroom. Even though students cannot see the entire operation, they can at least see components of how industry uses renewable energy technology. One partner suggested videotaping a tour for more dangerous or sensitive areas that students could not access due to heavy machinery or conservation issues.

Another partner pointed out that since many of these businesses are smaller, most of them don't have the time to constantly conduct tours and teach science firsthand to students because they have to run their business. The partners discussed better ways to provide information, education, and experience to bigger groups of people. On the practical side, one partner suggested that a better, more effective plan needed to be developed in this partnership. Some of these businesses have also been working with school districts to help provide alternative energy curriculum.

One aspect of LEADERS that has not fully developed yet is for TLs to pursue external funding to continue their projects and field trips. While the business liaison provides opportunities for external funding to the TLs on a regular basis, the TLs have not, at least from the business partner perspective, pursued funding. Several partners said that the teachers have noted being overwhelmed by new content and other responsibilities associated with being a TL (e.g., providing professional development), but glad because it has pushed them to improve. One partner suggested that a single TL might be charged with spearheading the funding aspects only because it is a time consuming process over and above time spent in the classroom.

When asked how they viewed their role in LEADERS, several felt they played an important role in coordinating the advisory board activity and meetings. Other partners felt that they provided a business perspective and tied that perspective into local science education to show opportunities available and how science education and industry work together. One partner felt that their involvement provided avenues for future development and resources for other groups to pursue. Several business partners noted how teachers felt exposure to the business partners was beneficial and advocated more interaction.

To determine their understanding of LEADERS, the partners were asked if they were familiar with the national and state science standards for k-12. Several business partners were aware that the standards were changing. This has allowed some of the partners to visit the classrooms and assist teachers with content not previously taught. This in turn provides important interface and interaction with the teachers. However, the only specific information business partners learned about state standards came through personal connections such as being parents themselves or having relatives that are teachers. One partner thought it ironic that the people who work in science fields are not consulted or included when the state develops standards. One partner expressed concerned over the fact that the Ohio-centric curriculum did not include anything on such vital topics as Lake Erie or the Great Lakes. The content covered, such as endangered species in Africa, is important but the partners felt that students should learn about the issues in their own community or region. One partner noted that the Great Lakes are important to the entire country—much more so that animals in Africa. Several business partners acknowledged further collaboration beyond LEADERS. Several groups work with schools in the communities where they are located and help out by tutoring and contributing some funding.

Finally, the business partners shared a positive impression of the TLs and their efforts. They noted that the TLs were knowledgeable and even some of the more veteran teachers showed a renewed vigor. The network and transference of ideas and information is cause for hope among the business partners regarding the future of education in the area. The sentiment was echoed that there has to be a better way to make the information available to all teachers and not just the one or two who contact the business for information or tours. The conversation concluded with a consideration of how technology could be implemented to bring this information to the teachers and students. It was noted most schools no have distance learning technology and that this could be feasibly implemented to increase exposure to the role of science in local business and industry.

VI. Summary

Cohort 1 TLs have shown significant changes in their beliefs about science instruction and in their role as teacher leaders within their districts. Cohort 2 TLs show some gains in the area of leadership development—comparable to Cohort 1 at the same point in the project. Overall, TLs have become more confident in their ability to provide high quality instruction, in their belief that quality instruction will result in greater student learning and in their confidence that they can perform the leadership roles prescribed in the project. Using PBS in their classrooms and teaching it to other teachers has improved their ability to implement PBS as it is designed to be implemented but there are still shortcomings. District teachers who attended PD find it to be a valuable resource that they will include in their science teaching. The district teachers appreciate the opportunity to see science instruction differently allowing them to reflect on better ways to teach science to their students. While student outcomes have not shown statistical gains, it is expected that changes at the student level will take much longer to enact as there are many factors affecting student learning.

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APPENDIX

LEADERS 2012 Cohort I Case Study Methodology

Eight of the Cohort I teacher leaders have been chosen to participate in in-depth case studies in order to better understand the impact the LEADERS Project has had on their understanding and use of PBS pedagogy. These case studies will utilize three main sources of data: lesson plans, interviews, observations, and student artifacts. These data will be analyzed collectively to provide a substantive and summative evaluation of their PBS knowledge and skills after three years of intensive study and PD delivery through the LEADERS Project.

The analytical frame that will be used for this is based on the PBS Rubric that was developed by Lisa Brooks in 2010. This rubric is largely based off the book *Teaching science in elementary and middle school: A project-based approach* (Krajcik & Czerniak, 2007).

Lesson Plans:

These questions will hopefully be answered in the lesson plans we receive before the observations. *If not, they should be addressed in the post observation interview*

- How many days/classes will the unit span?
- What is the driving question?
- What are the overall learning goals for the unit?
- Do learning goals have a connection with renewable energies and/or the economy and industry of the Great Lakes Region?
- How do these learning goals connect with course of study and/or state standards?
- How will students develop researchable questions?
- What questions will students explore or (if students will generate research questions) what questions do you anticipate them coming up with?
- How will students develop the methods to answer these questions?
- How will students collaborate or work in groups during this unit?
- What data will students collect and/or analyze?
- How is technology incorporated into this unit?
- What tangible product or project will students produce?
- What opportunity will students have to reflect on, revise and/or repeat their questions and methods?
- How will students learning and performance be assessed? (Ask for copies of assessment instruments and/or copies of student work. If copies are not possible take pictures).

Observations:
Observations will take place twice a year—fall and spring semesters. Teachers will be asked to invite an observer a minimum of two days per week during their PBS implementation for up to three weeks. It is anticipated that the majority of PBS units will span at least two or more weeks. This should provide 4-6 observations of each teacher’s unit. PBS should mirror scientific investigation and therefore, if possible, instances of each of the following elements should be observed over the course of the 4-6 observations:

- Introduction/Engage/Gathering knowledge/Immersion into phenomena
- Generation/Negotiation of Research Question
- Experimental Design
- Experimentation
- Data Analysis
- Conclusions/Reflection/Revision of research questions

Three instruments will be applied to these observations. The ITC COP observation (Horizon) instrument will provide a method of aligning the quality of the lessons with reform-based teaching ideals. The M-SCOPS will provide insight into levels of teacher direction and higher-order thinking. The PBS rubric will be used as a guide during these observations to ensure the observer can make a qualified judgment about each PBS element.

Interview:

A post-observation interview will be conducted with each teacher no more than one week after the final lesson is observed. The purpose of this interview is twofold. First it will increase the observers' understanding of the teachers' goals and decisions about their unit and its implementation. Secondly it will explore how they understand the features of PBS and how they applied their understanding in the design and delivery of their PBS unit.

<u>Unit Overview:</u>

- How many times have you implemented this PBS unit prior to this time?
- Overall, how do you feel about how your PBS unit played out?
- What do you think students gained from your PBS unit? Do you feel your students met your learning goals?
- How do you see the learning that occurred fitting into State standards?
- Were there any major hurdles you encountered trying to implement this PBS unit? If so, how would you modify the lesson next time to address these hurdles?
- Do you normally teach science the way you taught this unit? What is similar or different about the way you taught this unit from a "typical" science unit?
- Did you notice any difference in how your students responded or learned from this unit as compared to what you've done in the past?
- Has your school administration been supportive of your efforts to implement PBS in your classroom? How or how not?

<u>PBS Understanding:</u>

- On a scale of 1-10, with 10 being perfectly and 1 being not at all, how well do you think your unit reflected the PBS pedagogy? Why do you rate it that way?
- What specific elements of PBS did your unit demonstrate? Can you give me examples?
- Would you modify your unit to be better aligned with the PBS pedagogy or do you feel it is aligned?

Driving Question:

- Why did you choose the driving question you did for this unit?
- In what ways was your driving question relevant, meaningful, important and interesting to your students?
- How well do you feel your driving question and unit helped your students gain an understanding of what scientists actually do?
- How did your driving question and unit relate to the renewable energies content you learned about through LEADERS?

Unit Reflection:

- Do you think you will repeat this unit next year? (If not, why not?)
- If you were to do this unit again, what changes would you make to it other than any you have already mentioned?
- Do you think your ideas about PBS have changed over the course of your participation in the LEADERS Project? If so, how? What do you think caused these changes?
- Is there anything else you would like to add?

Student Artifacts:

PBS should result in a project or product designed by students. The researcher should collect copies and/or photographs of these products to enhance understanding of how well students met the learning goals that were outlined in the lesson plans, and how the end product conformed to a PBS approach.

Synthesis:

The PBS Rubric will provide the analytical frame for the analysis of these data. During observation and interviews the observer should refer to this rubric to ensure there is adequate justification for ranking each element. Case study reports will include rich descriptions of observed lessons with instrument ratings, supporting lesson plans and materials, descriptions of student assessments and final products, and descriptions of teachers' reflections on their PBS implementation. Once case study reports are completed cases will be synthesized and cross-case comparisons and conclusions will be made.