NSF MSP LEADERS Project

Evaluation Report

Year Three

June 1, 2011 -May 31, 2012

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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 2011 through May 2012.

Executive Summary

Evaluation efforts during Year 3 closely followed the revised project evaluation model (per Year 1 and 2 recommendations). A few additions were made to the evaluation model to better measure the partnership. Specifically, the social network analysis piloted during the summer 2011 was modified to allow for the examination of more complex relationships. The evaluation team, in cooperation with the project research team, has also been developing a Levels of Leadership assessment that will classify where in the spectrum of leadership development the teacher leader resides. The project team has also been developing a model of PBS learning progressions that could be useful to PBS research and measurement of teacher mastery of PBS strategies.

Teacher Leaders continued to show improvement in the area of science teaching self-efficacy. While the Teacher Leaders appear to be gaining at different rates (based upon a repeated measures analysis), they are all becoming more confident in their ability to provide high quality science instruction as well as increasing their confidence that high quality instruction will indeed result in more student learning. The Leaders also continued to prefer inquiry based instructional strategies over non-inquiry at a 1.8:1 ratio (Year 2 was 1.6:1). The Teacher Leaders also increased the amount of confidence they have in enacting the leadership responsibilities associated with the project but do not see these responsibilities as a major part of their position within the school district.

Findings from qualitative investigations of Teacher Leaders’ beliefs and understanding of project based science did not change from the previous year. Some Teacher Leaders appeared to gain in their propensity towards reformed-based teaching and understanding of the hallmarks of PBS while others seemed to regress. No distinct pattern in changes was identifiable (e.g., by district or grade level) except that several of the TLs have changed teaching positions over the last year (different schools, different grade levels) this could have an influence on the degree to which they embrace reform-based teaching. These mixed-results indicate that in the short term the program may be influencing participating teachers in different ways.

Most classroom observations of the Teacher Leaders delivering a PBS lesson were disappointing. It was difficult to tell whether the Teacher Leaders had a genuine misunderstanding of what makes up a PBS lesson or whether some Teacher Leaders scheduled a “convenience” observation just to get it out of the way. Next year we will require that the Teacher Leaders schedule observations during the implementation of lessons designed during the 2012 Summer Institute.

District teachers who attended the LEADERS professional development sessions hosted by the Teacher Leaders rated the session highly and appreciated not only the content and lessons but also the opportunity to develop a community of learners with colleagues. They liked the schedule changes that resulted from last year’s feedback and felt that the content was grade level appropriate. The teachers specifically mentioned inquiry based instruction, science journaling, and integrating science across disciplines as instructional strategies they learned through the sessions. They particularly appreciated the resources the Teacher Leaders provided and felt that the focus on renewable energies helped make the energy units they had previously “just gotten through” relevant and important for their student’s futures.

Social network analysis showed that the Teacher Leaders have improved their use of a variety of resources in comparison to last year. Their use of a variety of LEADERS resources for content and pedagogy in their teaching and as they create and implement professional development has improved. They have weaker linkages when asked about the use of resources to connect science to local renewable energy indicating this is still an emerging area of focus. In general, LEADERS resources are used most frequently for the purposes of attaining information. The second most frequent use overall is to get advice.

Finally, Teacher Leaders showed statistically significant gains in content knowledge over the course of the Summer Institute 2011. Teacher Leader feedback on the Institute was positive indicating that many of the "kinks" present during the first have been "ironed out".

Data were collected from the treatment and control school teachers on the STEBI, STIPS, and renewable energy content fall 2011. Response rate was similar to the previous year. There was no statistically significant difference between treatment and control school teachers on the renewable energy content test and in both cases performance was low (58%). While last year's analysis showed the test to be reliable, it's validity is in question as, while it covers basics of renewable energy and was developed by the project faculty, it does not necessarily match *what the TLs are teaching to their teachers.* Prior to the administration of a district teacher content test for Year 4, it is recommended that the TLs review to provide evidence of content validity.

Scores on the STIPS were similar between groups with both preferring inquiry based instructional strategies over non-inquiry at a ratio of about 1.33:1. Treatment teachers scored statistically significantly higher on the Personal Beliefs scale of the STEBI however suggesting that those teachers who have attended the professional development sessions have increased their confidence in their ability to provide high quality science instruction. There were no differences in scores on the Outcome Expectancy scale (the belief that high quality instruction can result in greater student learning) most likely because urban teachers often feel there are other factors beyond quality instruction that contribute to the degree of learning a student might attain.

Student achievement on the Ohio Achievement Test in Science was not statistically significantly different between control and treatment schools. Nor was there a difference between students on the attitudes about science survey. In general, both groups of students will consider a career in science. Both groups also had difficulty agreeing with items concerned with renewable energy as being a part of protecting our environment (this survey was administered spring 2011) verifying that a project such as LEADERS that links renewable energy science with school science curriculum is needed. A content test on renewable energy was administered to 6ht and 8^{th} grade students fall 2012. Groups were equivalent on this test. The posttest was administered May 2012 and findings from comparisons will be included in the Year 4 annual report.

Finally, during the past year the Network Coach worked to engage business and industry partners for the project. We are currently in the process of conducting brief interviews with these identified partners and will report our findings in the next reporting cycle.

Overall, the project continues to show improvement. Each year Teacher Leaders are becoming more knowledgeable, more confident, and more proficient in the delivery of quality renewable energy and project based science professional development. District teachers are showing some positive outcomes as a result of participating in the professional development sessions.

I. LEADERS Evaluation Model

Data collection followed the evaluation model closely this year. District teachers were surveyed in the fall and students were assessed in October and May to examine change over time. Logistical problems gathering data from school district teachers and students experienced last year were minimal this year as more time was spent ensuring that principals understood the process and informed their teachers and staff. Teacher Leader (TL) professional development workshops for district teachers were spread out throughout the year and feedback was collected from the district teachers who attended during the first and last sessions. Focus group interviews with the participating district teachers were conducted at the last session.

Some new features have been added or are in the process of being added to the evaluation model. First, a *social network analysis* (SNA) survey for the teacher leaders was piloted. The results were shared at the 2012 NSF MSP conference in January. Working with the LEADERS research team, the evaluators developed a survey that examines the extent to which TLs interact with various components of the partnership (see Appendix for a copy). The survey examines frequency through three constructs: (1) to support the TL's own classroom teaching; (2) to support the preparation and delivery of project based science (PBS) professional development; and (3) to support the TL's role as a coach for science education peers. For each resource of the partnership, the TLs indicated whether the resource was used to support science content, PBS pedagogy, or both.

The SNA survey also explores the nature of the TLs' interaction with the resources or partnership components. Social networks play a huge role in educational change and the dynamics of the networks are necessary to understand the condition and processes that sustain or hinder change, especially where educational reform is concerned. The examination of social networks among TLs and school leaders, the contrasting formal and informal organizational structures, access to and leverage of existing conditions in professional interactions and relationships, and the mechanisms by which ideas, information, and influence flow from person to person and group to group contribute to the powerful influence of the relational ties that support or constrain the pace, depth, and direction of change. SNA, through the various lenses, clearly shows the expansion of teacher professional knowledge, and the diffusion of innovative practices. Finally, the survey explores whether TLs have recommended the resources to others. For those resources they have not recommended we probed to determine the reasons. Results of our first administration of this instrument are provided in Section II.

Another instrument under development by the research team in collaboration with the evaluators during the reporting period is the *Levels of Leadership Assessment*. Our goal is to align the instrument with the seven domains of the Teacher Leader Model Standards (http://www.teacherleaderstandards.org/index.php), which has guided the leadership classes. The domains include a list of functions that a teacher leader who is an expert in that domain might perform. These include:

1. Fostering a collaborative culture to support educator development and student learning
2. Accessing and using research to improve practice and student learning
3. Promoting professional learning for continuous improvement
4. Facilitating improvements in instruction and student learning
5. Promoting the use of assessments and data for school and district improvement
6. Improving outreach and collaboration with families and community
7. Advocating for student learning and the profession
8. Advocating for student learning and the profession

Our rubric will include levels of development pertaining to the domains and will be categorized as emerging, developing, proficient, and expert. This assessment will triangulate our evaluation of the TLs and will be correlated with other measures of TLs (e.g., STIPS, STEBI, LEADERS Leadership Inventory) to obtain a clearer picture of TL development. Findings from this instrument will be reported in the Year 4 Annual Report.

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 noted in the Year 2 Evaluation Report, the Horizon may not adequately assess the complexity of PBS mastery and therefore use of it alone to measure PBS may lack validity. The evaluation team, in collaboration with the LEADERS leadership team, has been examining other possible, valid means by which to examine district teacher PBS mastery during years 3-5 including examination of extended lesson plans and in depth case studies of a few randomly selected teachers. We are currently researching the development of PBS learning progressions that could be useful in determining the extent to which teachers have mastered the implementation of this instructional strategy. Table 1 (page 7) presents only the components of the LEADERS evaluation plan that have been completed during the current reporting period. In addition to data discussed earlier, TL classroom observations and interviews and data collected during the Year 2 Summer Institute are reported.

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--Horizon	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)	Horizon Observation Protocol	Evaluator	annually
1-5	Implementation of PBS (teachers in district--random sample)	Horizon Observation Protocol	Evaluator	**Eliminated**
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	annually
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	**annually**
1-5	Understanding and implementation of PBS	Review of teacher leader Five E model lesson plans (rubric)	Project developed	annually

3 & 5	Improved student learning	Ohio and Michigan 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 (scheduled but not collected till fall 2011)	Renewable energy content tests	Project developed	Pretest/posttest
5	Impact of MSP on IHE faculty	Survey covering how MSP has affected research, understanding of state content standards, expectations of science preparedness of HS grads, understanding of MSP collaboration	Project 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	Survey covering research partnerships, understanding of state content standards, grades 4-12 science preparation, and policy changes due to MSP collaboration.	Project developed	Annually

II. TEACHER LEADERS

This section includes data collected from Cohort 1 and Cohort 2 TLs. Cohort 2 data is baseline. As in previous years, quantitative instruments coupled with personal interviews were employed to measure change in TL attitudes, confidence, and ability. Results concerning content mastery gained from the Year 2 Summer Institute are included in this report as the Institute took place July 2011. 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.

A. Science Teacher Efficacy Beliefs Instrument

The STEBI (Enochs and Riggs, 1990) has been used over the past two years as a measure of teacher leader development. There are two subscales. Outcome expectation or 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 professional development in the integration of renewable energy science into their classrooms using PBS.

Because the STEBI scale is ordinal, it is inappropriate to calculate mean scores and make comparisons between scores using parametric analyses. To correct for this, last year we utilized Rasch modeling to convert the ordinal scores to an interval scale. 2012 scores were anchored to the baseline (district teachers, 2010) and a repeated measures analysis was performed to compare 2010 with 2011 and 2012. Table 2 provides mean scores for Cohort 1 for each year, effect size gains, and a repeated measures analysis. In addition to Cohen's *d* (effect size), we calculated Cohen's U_3 (1988) to illustrate the typical percentile gain the average participant (50th percentile) could expect (Valentine and Cooper, 2003).

Table 2: STEBI Scores for Cohort 1

	Mean	Standard Deviation	Cohen d	Cohen u	Repeated+ Measures
Cohort 1 Personal Beliefs					
2010	46.15	4.59	n/a	n/a	n/a
2011	47.89	8.46	0.20	0.58	n/a
2012	52.60	6.82	0.55	0.71	1241.54*
Cohort 1 Outcome Expectancy					
2010	35.41	22.02	n/a	n/a	n/a
2011	46.75	18.85	0.52	0.70	n/a
2012	48.57	11.55	0.18	0.57	F= 173.58*

+Between contrast *p < 0.00

Table 2 illustrates that the TLs continue to increase/improve on both scales. On the Personal Beliefs scale, there was a statistically significant gain from the first testing to the most recent (Repeated Measures column). There was also a within contrast effect ($F = 23.82$; $p = 0.001$) indicating that some of the TLs increased at statistically significantly higher rates than others. The effect size gain from 2011 to 2012 was medium with the average respondent (one who fell in the 50% at the time of the second testing) expected to move to the 71st percentile on the most recent test. When compared with the contrasts between Year 1 and Year 2, Year 3 has shown greater gains in TLs' belief that they can provide quality science instruction.

Scores on the most recent administration of the Outcome Expectancy scale also indicate a statistically significant gain between Year 1 and Year 3. There was no within group significance which suggests that no one TL advanced more rapidly or slowly than another. While TLs felt more strongly that quality science instruction can enact positive change in student learning, the gain this year over last year was not as large (small effect size and expected change in score from 50th to 57th percentile). *It is not expected that statistically significant increases in scores will occur each year—particularly with such a small sample size. It is noteworthy that scores continue to increase and any statistical significance is exemplary considering we are working with a sample of 12.*

Cohort 2's baseline scores on the STEBI illustrate that this cohort has some general differences from Cohort 1 in the area of science teaching efficacy. Cohort 2 scored a 50.22 on the Outcome Expectancy scale as opposed to Cohort 1's mean score of 35.41 at baseline. Cohort 2 has much more confidence that quality instruction will lead to better student learning. Cohort 2 is composed mainly of teachers from the Monroe School district (Michigan) which, while urban, is a much smaller community than Toledo. In contrast, the Personal Beliefs average for Cohort 2 was 42.85 versus the 46.15 average for Cohort 1 suggesting that Cohort 2 is coming in with less conviction than Cohort 1 as to their ability to provide quality instruction. While this comparison is interesting, there are no conclusions that can be drawn and it should be remembered that both Cohort baseline scores are well above the district averages of roughly 26 on both scales.

B. STIPS

The STIPS provided a measure of science teacher preferences for inquiry based and 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 1.6 to 1 ratio in favor of inquiry based instructional strategies and TLs ranked above the expected mean on the inquiry scale and below the expected mean on the non-inquiry scale (as hoped). This year the preference for inquiry based instruction rose to a 1.8 to 1 ratio. Cohort 2 data is baseline. They begin with a 1.5 to 1 ratio in preference for inquiry based instruction which closely reflects the district teacher preferences.

Last year, the item that was the hardest for TLs to agree with on the inquiry scale was, "The student should figure out on his or her own the important concepts of the materials being studied rather than receiving them directly from the teacher." While that continues to be the most difficult item to agree with, none of the items scored more than two standard deviations outside of the mean indicating that in general the TLs tend to come to a consensus on the items. This, coupled with the increase in the TLs' preference ratio, indicates a move towards accepting all aspects of inquiry based instruction.

Two items on the non-inquiry scale scored more than two standard deviations from the mean and both had to do with lab experiments. This means that TLs were widely split in their response to these items: "lab experiments should be designed so that the correct results or answers will emerge for only those who follow the directions and procedures" and "The primary objectives of lab experiments should be the development of manipulative skills and ability to follow directions, which lead to planned results." Overall, TLs tend to rate these two items as either "strongly agree" or "strongly disagree". Apparently, some of the TLs are embracing a key component of project based science while others are still resisting it.

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. Cohort 1 responded with a 3, 4, or 5 to the **leadership responsibilities** 81 times. Cohort 2 only responded 19 times; however, there are no expectations that Cohort 2 would assume the leadership roles of LEADERS prior to participation in the project. As far as **confidence enacting these leadership responsibilities**, the two cohorts were comparable with Cohort 1 providing 129 positive responses and Cohort 2 with 119. **So while they have the confidence to take on leadership responsibilities, they do not feel they are in a position to do so.** Table 3 provides a clearer picture of the responsibilities and which areas the TLs have the most responsibility.

Table 3: Cohort 1 Teacher Leader Leadership Responsibilities

Area	Some responsibility	A moderate amount	A great deal
Organizing and facilitating professional learning communities for science educators	5	3	0
Working with science educators to determine their professional learning needs	6	3	0
Designing customized professional learning opportunities and programs for other science educators	4	4	0
Coaching or mentoring other science educators	8	1	0
Being an advocate for science activities and strategies	7	4	0
Representing your school and district at professional meetings and conferences	5	4	0
Assessing the effectiveness of professional learning programs and processes for educators	3	3	0
Providing resources and research related to science reform to other educators	5	5	0
Working with scientists and industry partners	4	0	0
Involving parents and the community in enhancing science education	2	1	0
Providing energy-related content support to other science educators	5	3	0

The responses to some items are somewhat puzzling as, for example, the TLs have been responsible for developing energy-related content support to other science educators since they joined the LEADERS project and when compared with others in their district they carry the sole responsibility. And yet Cohort 1 had a median and mode of "some responsibility" on that item. During the upcoming Summer Institute, the evaluation team will explore in more depth why the TLs in Cohort 1 responded as they did. It may be that the terms used in the rating scale are ambiguous or that the TLs are comparing the amount of time spent carrying out LEADERS responsibilities with their time teaching (i.e., measuring time spent rather than actual weight of responsibility).

D. Teacher Beliefs Interview (TBI)

TLs were interviewed a second time during the 2011/2012 academic year using the TBI (Luft & Roehrig, 2007). This tool incorporates a standardized way to quantify and compare teachers' beliefs within and across cases. There are seven questions included in this interview:

1. How do you maximize student learning in your classroom?
2. How do you describe your role as a teacher?
3. How do you know when your students understand?
4. In the school setting how do you decide what to teach and what not to teach?
5. How do you decide when to move on to a new topic in your class?
6. How do your students learn science best?
7. How do you know when learning is occurring in your classroom?

A coding scheme for each question allowed TLs' responses to be categorized into one of five orientation categories. These categories ranged from traditional (1) to reform-based (5). Research demonstrates that it is easier for teachers to adopt classroom practices that are aligned with their orientation toward science teaching (Luft & Roehrig, 2007; Magnusson, Krajcik, & Borko, 1999). PBS is a reform-based approach to teaching and therefore it would be expected that teachers with orientations closer to the reform-based end of the spectrum would be better candidates for a project such as LEADERS. Those with more far-removed orientations may require additional support or time to acquire the same skills and abilities. Furthermore, it would be expected that immersion into a teaching method such as PBS would encourage teachers to adopt more reform-based beliefs about science teaching.

TLs' responses to the TBI were recorded and transcribed. Results from this year's analysis are presented in Table 4. Table 5 provides a comparison of scores from this year and last year. The scores of two teachers are not included in this year's analysis as one teacher left the program and the other has been difficult to reach. Overall, changes in scores ranged from a decrease of 1.28 to an increase of .86. Four of the teachers appear to have had positive shifts in their responses to TBI questions, three appear to have moved away from reform-based orientations and three appear to not have changed. No distinct pattern in changes was identifiable (e.g., by district or grade level) except that several of the TLs have changed teaching positions over the last year (different schools, different grade levels) this could have an influence on the degree to which they embrace reform-based teaching. These mixed-results indicate that in the short term the program may be influencing participating teachers in different ways.

Table 4: Coded Responses to the 2011/2012 Teacher Beliefs Interview

Name	Traditional	Instructive	Transitional	Responsive	Reform-based
Amanda Emerson			*	******	
Sheri Jacobs			*	*****	*
Claudia Farley	*	*	*****		
Irene Hobart				**	*****
Rhonda Lipsey		***	***	*	
Heidi Conklin	NA				
Emily Bolen				*******	
Beverly Magness		****	***		
Travis Wright	NA				
Lynne Brandt				*****	**
Deborah Samford		***	****		
Mary Rhode			*******		

Table 5: Comparison of Average TBI Scores[*]

Name	2010/2011	2011/2012	Change
Amanda Emerson	3.57	3.86	+0.29
Sheri Jacobs	3.14	4	+0.86
Claudia Farley	2.57	2.57	0
Irene Hobart	4.28	4.71	+0.43
Rhonda Lipsey	3.28	2.71	-0.57
Heidi Conklin	2.86	NA	NA
Emily Bolen	3.43	4	+0.57
Beverly Magness	3.71	2.43	-1.28
Travis Wright	4.29	NA	NA
Lynne Brandt	4.29	4.29	0
Deborah Samford	2.57	2.57	0
Mary Rhode	3.14	3	-0.14

[*] Scores were calculated from responses to TBI questions using a scale of 1 = traditional and 5 = reform-based.

E. PBS Understanding

At the conclusion of each Summer Institute, TLs are asked to complete a survey that examines their knowledge of PBS. One item asks them to provide a personal description of PBS. These descriptions were scored for the presence or absence of eight common features of PBS agreed upon by experts (Marshall, Petrosino, & Martin, 2010) and include: (1) driving question; (2) learner product; (3) investigation; (4) assessment; (5) tools; (6) collaboration; (7) scaffolding; and (8) length. The tables below compare the frequency of these features included in individual teacher responses and across all teachers for both years. Definitions were assigned one point for each of the above features that were mentioned. Only 7 TLs completed the survey in 2010 so conclusions as to gain in understanding cannot be made across the cohort.

Table 6: Frequency Count of PBS Features in Individual Teacher Definitions

Name	2010 Survey	2011 Survey	Change
Amanda Emerson	2	4	+2
Sheri Jacobs	NA	0	N/A
Claudia Farley	2	3	+1
Irene Hobart	NA	4	N/A
Rhonda Lipsey	NA	0	N/A
Heidi Conklin	1	2	+1
Emily Bolen	2	1	-1
Beverly Magness	1	0	-1
Lynne Brandt	2	1	-1
Deborah Samford	NA	2	N/A
Mary Rhode	2	2	0

Table 7: Frequency Count of PBS Features Included Across Teacher Definitions

Feature	2010 Survey	2011 Survey
Driving Question	43%	27%
Learner Product	0	27%
Investigation	0	55%
Assessment	0	0
Cognitive Tools	0	0
Collaboration	58%	18%
Scaffolding	14%	9%
Extended Length	0	36%
Student-driven	43%	55%
Real-world	29%	27%

Table 7 breaks the references down by the features. Two additional features were mentioned by multiple teachers: student-driven and real world. The definitions TLs provided on the 2011 PBS surveys included six of the eight core features agreed upon by experts as compared to three in 2010. The TLs also mentioned that PBS was student-driven more often and that it included student collaboration less often than they had in 2010. These frequencies provide evidence that some of the TLs' understanding of PBS has expanded to incorporate features that were not mentioned last year. It also suggests that they may be focusing on different aspects of PBS than they were in 2010.

Frequencies demonstrated that the core features of PBS are still not easily recalled by the TLs. No single teacher mentioned more than half of the essential features. Only two TLs did mention half, while five mentioned only one or two and, three did not mention any. The features mentioned within personal descriptions also varied a great deal across responses. Finally, it should be noted that this method of investigating TL understanding of PBS is open-ended (as opposed to picking hallmarks from a list) so it measures more than just the ability to identify the features—it determines whether the TLs have a strong working definition of their own.

F. PBS Classroom Observations

In October 2011, TLs were asked to schedule an observation of their implementation of a PBS unit in their classroom before the end of the fall semester. Six of the teachers did so immediately and one informed us that she did not have a classroom of her own in her new position as a district science resource person and would more than likely be unable to schedule anything until the spring.

While many of the teachers tried their best to provide an observation of a lesson they felt demonstrated their understanding of PBS and renewable energies, there were several who did not. It is difficult to conclude from these observations if these TLs lack an understanding of PBS and struggle to connect renewable energies content to their curricula or if they just scheduled the observer to view any science lesson. Exit interviews will be added to next year's observations to determine why TLs selected the lesson they did and how they felt it fit in with PBS. The following section presents a brief description of the observed lessons. The connections between each lesson and the project goals that were observed are summarized in Table 8.

Lesson Descriptions:

Sheri Jacobs (1): This 7th grade lesson was focused on introducing students to the impacts and difficulties of cleaning up the Gulf Oil Spill. Students made observations of feathers, viewed pictures and videos of birds affected by the 2010 oil spill and planned how they might use the available materials to simulate an oil spill in the classroom and experiment how oil and water could be separated. This lesson did not appear to have a strong PBS-like driving question but it did appear to be a good example of a student-centered classroom investigation that connected to the real world and renewable energies content.

Claudia Farley (2): This 2nd grade lesson was focused on helping students to understand what composting was and what materials could be composted. Students played a game in which teams sorted index cards into piles of "recycling, compost, or garbage." They discussed what the compostable items had in common and spent time designing a compost bin they would create the next class period. While the lesson was designed in the spirit of PBS, it appeared a good deal more teacher scaffolding was needed to be successful. Maintaining student focus on meaningful learning was problematic as they were asked to complete tasks (i.e. design a compost bin) that appeared to be beyond their realm of experience and knowledge.

Irene Hobart (3): Irene's situation was unique among the TLs. She was given the position of science resource person for the district as many teachers were transferring to new roles due to district restructuring. I observed her teach a 7th grade class that she visited several times a month. This lesson was part of a series of lessons focused on understanding the properties of waves. Students experimented with Slinky's to understand how waves behave when they move through different materials and encounter different substances. The lesson was well designed and engaged students in investigation. It incorporated many of the features of PBS and the interview with Irene demonstrated that she had a clear vision of how it would segue to a more explicit focus on renewable energy content.

Heidi Conklin (4): This lesson focused on student's understanding of different types of renewable energies. Students collected data from an experiment prescribed in the workbook that came with a set of Styrofoam solar houses she had purchased for her class. The experiment appeared to be one in a series of verification labs. This lab illustrated the difference between passive and active solar energy. Students went outside to collect data about the internal temperature of their solar house every ten minutes. In between data collection students returned to the classroom to take notes from teacher lecture about coal and nuclear energy. This lesson was highly connected to content about renewable energies and represented either early stages of investigative science and PBS-pedagogy or a benchmark lesson to set the stage for further investigation.

Deborah Samford (5): For the first 15 minutes of the observed 8th grade class students completed a benchmark exam. After a short discussion about recent weather conditions, the teacher navigated the NOAA website and instructed students to copy down information about temperature, cloud cover, and precipitation in their science notebooks. Deborah expressed that her students had been collecting data in a similar fashion from the NOAA site over time. Her goal was ultimately for students to understand weather patterns and be able to navigate the site by themselves. Serious classroom management issues compounded the potential of the lesson. It was unclear how the use of the NOAA website in this fashion connected to PBS pedagogy or investigative science. It was related to renewable energy content although the teacher did not make that clear.

Rhonda Lipsey (6): This 6th grade lesson was part of a lengthy unit driven by the question: “Can we grow salsa.” During the unit students collaboratively decided on a salsa recipe, learned about the plants various ingredients came from, tested soil, air and sun conditions to decide on the best place on school grounds for a garden plot, and designed how they would utilize a small 2’x3’ raised bed plot to grow the ingredients their recipe called for. During the observed lesson, students finalized their recipe selection, began drawing a design for their garden plot, and wrote a letter convincing readers why their recipe was the best choice. The design of the unit was a clear attempt at implementing long-term PBS investigation. However, based upon student engagement there appeared to be issues with the lesson’s design and appropriateness for the experience and knowledge level of students. This was connected to renewable energies later in the unit (per teacher lesson plan).

Amanda Emerson (7): This lesson was part of a unit on forces and motion that engaged 8th graders in designing and experimenting with balloon rockets. At the start of class Amanda led a brief review and discussion about the physics involved in the movement of a balloon rocket. For the remainder of class students worked in small groups to experiment with various shapes and size of balloons to design a rocket that would climb an anchored piece of string from floor to ceiling the highest and fastest. Students worked in small groups and several groups came up with inventive and successful designs. While this lesson was a good example of investigative science, it did not appear to be well aligned with many of the core features of PBS-pedagogy. The lesson also did not exhibit an obvious connection to renewable energies content.

Mary Rhode (8): Mary coordinated with another teacher to extend the length of her 8th grade class period the day of observation. During this time students designed Rube Goldberg models that had at least five energy transfers. When the observation began, the five groups of students had been working on their models for about an hour. Mary instructed the groups that were done to draw and label a diagram of their models before the end of class. For the last five minutes of class students explained their model. While the lesson did deal with energy concepts and renewable energy sources, the teacher did not make connections to renewable energy clear to the students.

Lynne Brandt (9): Lynne’s observed lesson occurred in the middle of a unit about wind turbines. During this lesson students were experimenting with variables involved in wind turbine blade design. This lesson was part of a longer sequence in which students had been out to visit a wind turbine near their school and had spent time thinking about the variables that could be experimented with. Students worked in small groups to develop a research claim about the shape, angle, or number of blades and a way to test their claim (e.g., eight blades will produce more energy than four blades will). Several groups completed their experimental design and began collecting data before the end of class. In her interview, Lynne stated the experimenting would continue for at least one more class. This lesson appeared to be well aligned with both PBS pedagogy and the renewable energy content taught during the summer institutes.

Beverly Magness (10): Beverly's observation consisted of two consecutive days with her general Biology class. These two lessons focused on the process of mitosis. Students were assigned a phase of mitosis and worked with a small group to create a paper plate model of the phase they were assigned. They were also asked to develop five test questions about their phase. Toward the end of the second class students presented their models and taught their peers a bit about the phase they had focused on. This lesson was not connected to investigative science, PBS, or renewable energies concepts.

Cross-case Analysis:

The lessons that were observed were highly variable in the connections to the content and pedagogy goals of the LEADERS Project. Observed lessons ranged from little connection to PBS or renewable energies to a great deal.

Looking across cases at the analysis presented in Table 9, four main areas where TLs may use additional support include: *driving questions, connections to the local economy, technology use, and learner products*.

G. PBS Professional Development Workshops (PD)

The Cohort 1 TLs worked in teams to develop and produce five PD sessions for targeted grade levels based on a driving question or theme. The groups were divided thusly: (1) Toledo Public Schools (TPS) grades 5 to 8 and high school Physical Science and Biology; (2) Toledo Catholic Schools (TCS) grades 2 to 5; and (3) TCS grades 6 to 8 and high school Physical Science and Biology. For TPS, professional development was provided to the whole group with grade level break-out sessions throughout the day.

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 based upon research on effective adult professional development. Scoring on the PD feedback form ranked the district teachers' level of agreement using a four point scale ranging from "not at all" to "to a great extent". 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 10 by group.

To augment information gathered from the feedback forms, each group of district teachers participated in a focus group interview at the conclusion of their last PD session. Information gathered from these interviews provided a richer picture of the district teachers' experiences and opinions about the PD. In general the majority of the teachers have attended at least three of the sessions and many indicated that they have been to all five. Last year the scheduling of the sessions was an issue with some of the teachers; TLs adjusted the schedule this year taking last

Table 9: Preliminary Analysis of LEADERS 2011/2012 PBS Observations

Did the observed lesson provide evidence of:

	1	2	3	4	5	6	7	8	9	10
A PBS-like driving question[1]?	○	○	○	●	●	○	○	●	◉	●
A connection to science process skills?	◉	○	◉	○	●	◉	◉	○	◉	●
An explicit connection to scientific concepts or content?	◉	○	◉	◉	○	◉	◉	○	◉	◉
An explicit connection to renewable energies concepts or content?	◉	●	◉	◉	●	●	●	○	◉	●
An explicit connection to the economy of the Great Lakes Region?	●	●	●	●	●	●	●	●	○	●
A scientific investigation[2] that extended over multiple days?	◉	○	◉	○	●	◉	●	●	◉	●
An opportunity for students to generate research question?	◉	○	○	●	●	●	○	●	◉	●
An opportunity for students to design and plan an investigation?	◉	○	●	●	●	●	○	●	◉	●
An opportunity for students to collect data through direct observation[3]?	◉	○	◉	○	●	○	○	●	◉	●
An opportunity for students to analyze, interpret and/or model data?	○	○	◉	○	●	●	○	●	◉	●
An opportunity to draw conclusions and/or communicate findings?	◉	○	◉	○	●	○	○	●	◉	●
An opportunity to use technology in the process of collecting or analyzing data?	●	●	●	●	●	○	●	●	◉	●
Was a product or project that had real-world value created?	○	●	●	●	●	○	●	●	○	●

Note. Symbols indicate the following: ◉=Yes, ○=Somewhat, ●=No. [1]In order to be classified as a "PBS-like" driving question the question needed to show evidence that it was (a) related to science content standards, (b) connected to real-world issues, (c) relevant to students lives, and (d) allowed room for students to pursue solutions over time.

[2]In order to be classified as a "scientific investigation" the teacher's discussion needed to show evidence that (a) a stated, explicit research question about the natural world was explored, and (b) a systematic method was used to address the investigation question.

[3]Collecting data through "direct observation" refers to students collecting data using their senses, not recording it from a book or website.

year's suggestions into consideration. This year, the majority of teachers said they enjoyed the format of the sessions (once per month). They appreciated the length of time in between sessions so they could take the ideas and try them out in their classrooms before returning to the sessions. The TPS group especially appreciated coming onto the university campus for the sessions as this location allowed them to pay more attention to learning since there were fewer disruptions such as students in the hall and bells.

When asked what some of the main things they had learned during the PD were, the teachers mentioned that they had learned that they really did need to give up some control over their classes. They had gained an understanding of why this was important and felt more confident and positive about really "getting into science" and helping students learn through hands on activities. One teacher pointed out that the sessions encouraged the teachers to actually "do science" in the classroom as opposed to teaching from the book. Another noted that the sessions afforded the time to talk to each other about the situations that they all deal with in the classroom because "we very rarely have the opportunity to be with colleagues in our own subject areas across the district and the same grade." They appreciated being able to try out the activities during the PD sessions and felt these opportunities allowed them to troubleshoot the activities and better understand how they would work in their classrooms. While teachers agreed that the instructional strategies they had learned were appropriate for their grade level, they were not all convinced that their own students were actually functioning at grade level so had some reservations about implementing some of the more complicated lessons. One teacher indicated that he/she might look at what was presented for a lower grade level and try that first.

Table 10: PD Feedback Summary

	Fall 2011		Spring 2012		
Group	Mode	Median	Mode	Median	Unusual items
TCS MS/HS	3	3	3.5	3	Spring: Scored a mode/median of "2" for *I learned new teaching strategies today; Appropriate connections were made to other areas of science and math, other disciplines, and real world contexts; and Adequate time and structure were provided for "sense-making," including reflection about concepts, strategies, issues, etc.*
TCS Elementary	4	4	4	4	
TPS	4	4	4	4	Fall: Scored a mode/median of "2" for *Extent of "sense-making" about classroom practice was appropriate for the purposes of the session and the needs of myself and other participants.*

Teachers were mixed in their responses to whether they learned relevant content. Some saw a clear connection between what they learned and what they teach but others did not see a link (e.g., life sciences). However, they all agreed that the teaching strategies they learned could transcend the content and can be applied to other topics. Strategies mentioned were inquiry, science journaling, and integrating content across disciplines. The teachers noted how much they liked the resource websites that were provided to supplement the material that was presented. They also commented that the TLs had made available the PowerPoint Presentations, which helped them become more comfortable presenting information to their students. They felt that the focus on renewable energies helped make the energy units they had previously "just gotten through" relevant and important for their student's futures.

When asked if they have or would implement PBS into their science instruction, respondents were not certain. Most indicated they have done "some" and that they believe mastery of teaching using PBS is not something they can learn in a few PD sessions. Those who attended last year as well as this year felt more confident and yet some actually offered that they thought last year that it would be easier than it is and now they are more hesitant. One teacher mentioned that this year was more informative than last year because mastering the complexity of PBS requires more than just a few sessions. While they all agreed this seems to be an effective way to teach science to most students, one teacher did point out that there may be some students who don't (or don't like to) learn this way. They felt PBS is a good strategy but that it should not be the only method of instruction. We asked those teachers who did not implement PBS in their classrooms if they had learned anything they had used in their classrooms. They responded that they had been listening more, letting their students talk more, and realized they did not have to feed everything to their students. Finally, most teachers felt they did not have the resources at their schools (supplies, equipment) to truly implement PBS as it has been presented to them at the PD sessions.

The teachers felt the best way the TLs could support their implementation of PBS in the classroom would be to be readily available. They wanted an easy and reliable way to communicate with the TLs and they wanted quick response time. Some mentioned that it would be valuable if the TLs could visit their class and assist in the lesson (this is actually the LEADERS design although the project has met some resistance from the TLs when it comes to taking time away from their own classrooms to help others). When asked how the PD sessions could be improved, the teachers suggested that a resource book that contained a variety of activities and experiments would help. They stated they had received a resource book last year but they really needed one that was strictly activities and places to start. They said it should include some information about the kinds and nature of the questions different grade levels might ask about a topic.

H. Science Café

Similar to 2010, the 2011 summer institute utilized five main pages on Science Café. Science Café is used as the main "outside the classroom" communication hub for the Summer Institute courses. As in the previous year, there was a homepage from which each of the four courses included in the institute could be accessed. An analysis of posts made during 2011 Summer Institute and the following academic year to the four course sites demonstrated the following:

- There were approximately 950 posts made across the four course pages (mean= 240; min = 75 posts to leadership course; max = 334 posts to Earth Tech course).

- Approximately 58% of these posts were required assignments, 37% were information uploaded by members of the project team or course instructors, and 4% were discussion posts by TLs or course instructors.
- Scientists appeared to customize their sites and utilize them as the main hub for course handouts and assignments.
- A total of 38 posts that demonstrated some level of discussion were made to three discussion boards. Other discussion boards were utilized but posts appeared to be shared assignments (i.e. posting daily content questions).
- Access of supporting partners was limited to the two administrators who had attended parts of the 2011 Summer Institute.

The number of posts and customization of the Science Café site increased a great deal over the previous year. However, except for a few instances of short discussion and one course instructor providing feedback on assignments, the majority of posts were of information uploaded by course instructors or required assignments uploaded by teacher leaders. It did not appear that content and pedagogy experts or the network coach were utilizing the site to network with TLs or the project team. This demonstrates that the usage of Science Café as a teaching tool has increased and improved over the last year but that the kinds of "productive and professional collaborations" described in the proposal are not yet occurring through the website but project staff are addressing this through other venues of communication. However, focus group interviews with the TLs last summer indicated that the TLs felt they communicated well enough using more traditional methods—telephone, email—and did not want to add one more "place to look" to stay current. On the other hand, based on comments from district teachers, a site (perhaps the LEADERS website) where links to lessons and resources can be easily accessed would be valuable.

I. Professional Networking

TLs completed the professional networking survey in May 2012. The survey was revised this year to include qualifiers or level of quality beyond just frequency of interaction (revised survey is in Appendix). 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. Examining responses from Cohort 1 and comparing with last year allows for observation of change. Cohort 2 data provides baseline for future comparisons.

We again used NodeXL to analyze the data. In this network analysis several variables were used to cross-reference the sample and provide more in-depth information—each main category (science content, PBS pedagogy, and showing connections of the local economy) was compared in relation to the subcategories (coaching fellow peers, engaging project-based professional development, and teaching science). The edge properties break-down is as follows:

- Width—frequency of using the named resource for coaching fellow peers
- Style—frequency of using the resource for project-based professional development
- Opacity—frequency of using the resource for teaching content

In each scenario, the wider and more opaque an edge is, the more frequent its use. Edge style was set to either be dashed (used less than monthly) or solid—solid indicating that the resource is used monthly, weekly, or daily. With regard to vertices, the relative size of each vertex is indicative of the percentage of professional development the participant links to classroom instruction and the relative opacity of each vertex indicates the percentage of NSF LEADERS material that is integrated into the participant's classroom instruction. For example, a large, very opaque vertex indicates a participant that links a high percentage of their professional development to their classroom instruction and they also integrate a high percentage of NSF LEADERS material into their classroom instruction.

First Cohort 1 will be examined followed by Cohort 2. Through observation of the "Teaching Science Content" histogram (Figure 1) we can clearly see several patterns. First, the internet has a high degree of traffic from the LEADERS participants—it is clearly a "go-to" resource. Second, the LEADERS personnel are used rather frequently, which is expected. Finally, we can observe that professional journals are frequently used as a resource. Resources that would be within the participants' home school districts also are used rather frequently, but not in comparison to the aforementioned areas. It is also clear that local professionals and university personnel are rarely used. The TLs are also incorporating high percentages of the professional development and LEADERS material into their classroom instruction.

Similar trends exist for the PBS pedagogy sociogram (Figure 2) for Cohort 1. First, there are high degrees of traffic using the LEADERS resources. Second, internet-based resources continue to be common areas for reference. Finally, resources within the district continue to be popular. Cohort 1 has clearly improved their use of a variety of resources in comparison to the first network analysis. The only areas of use they use infrequently are local professional scientists, business people, and community resources.

Figure 1: Cohort 1 Professional Network for Teaching Science Content

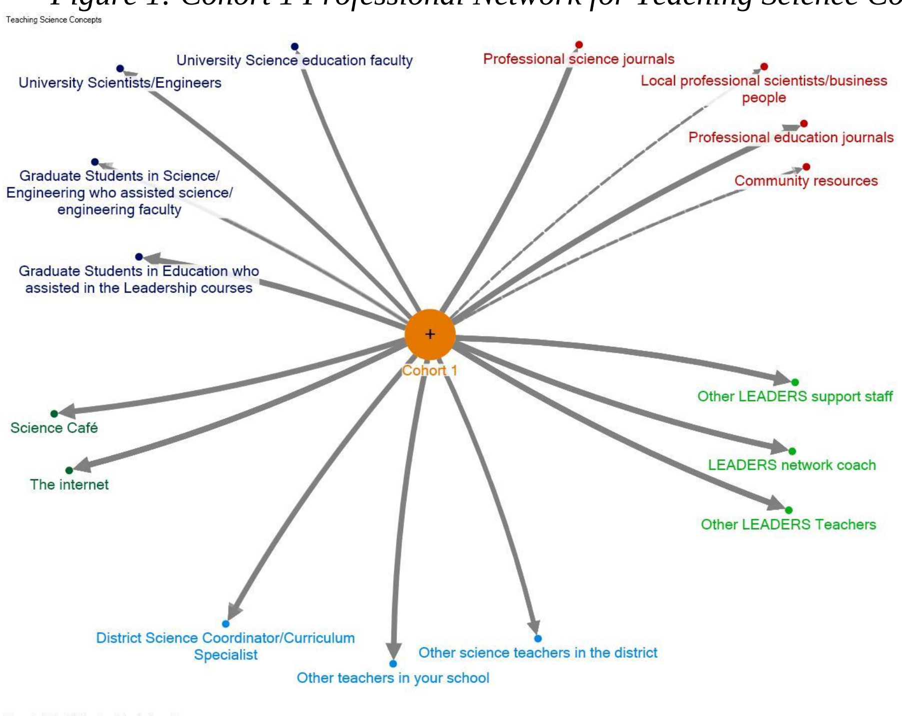


Figure 2: Cohort 1 Professional Network for PBS Pedagogy

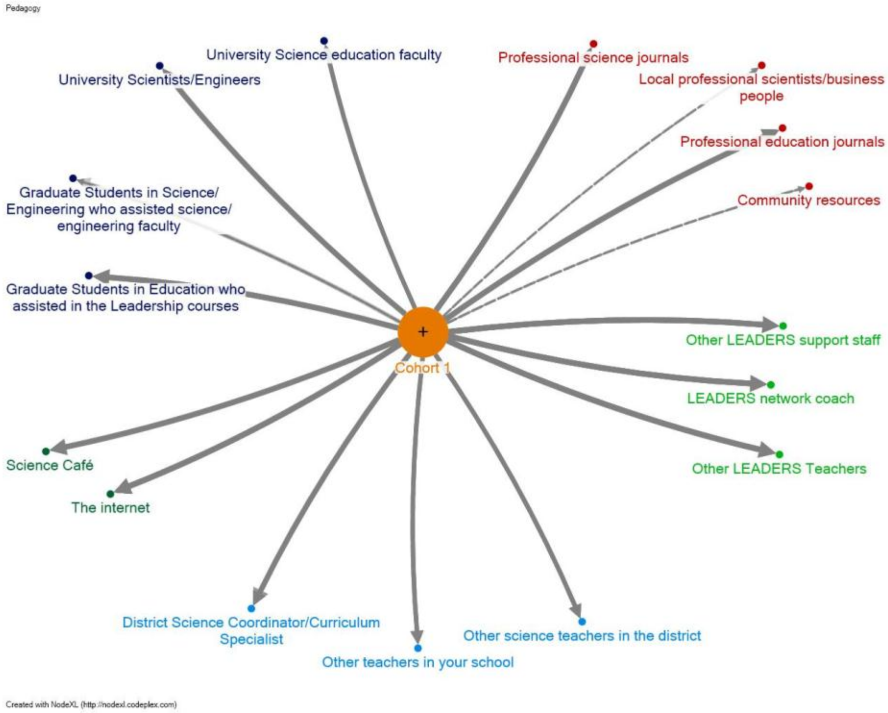
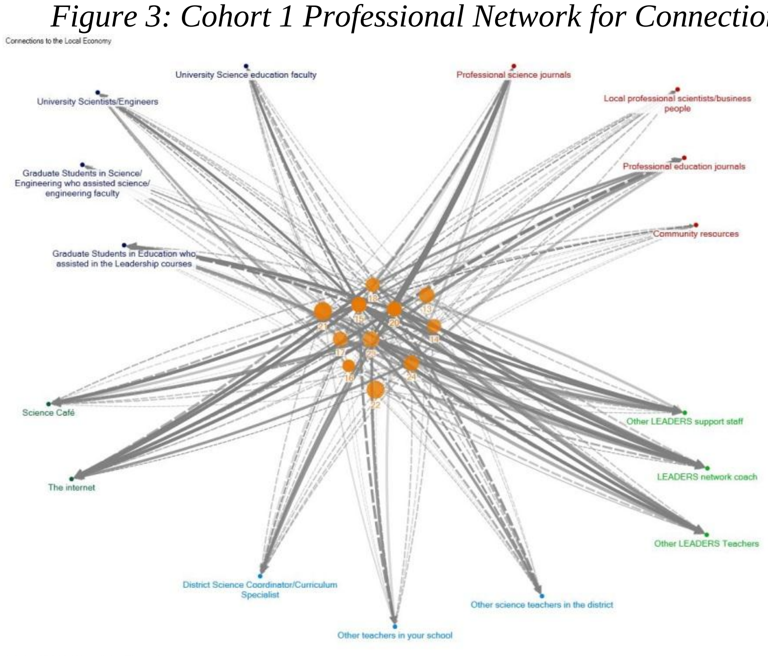


Figure 3: Cohort 1 Professional Network for Connections to Economy



The Connections histogram (Figure 3) is not nearly as dense as the previous graphs—it appears that forming connections to the local economy is something relatively new to the TLs and has not yet established marked degree of traffic in the network (note the frequency of dashed lines rather than solid lines).

Cohort 2 provides us with baseline information. Currently, this group rarely uses any resources and the resources they are using are isolated—for example, they are using the LEADERS network coach and other LEADERS teachers, but rarely engaging the LEADERS support staff. The same proves true for their own school districts—they communicate with their district science coordinators and curriculum specialists, but rarely engage other science teachers in their districts. We can also see that several of the second cohort's vertices are large, but quite transparent—this tells us that they are incorporating high percentages of their professional development into their classroom instruction, but they are not integrating the NSF LEADERS material into their classroom practices (which is expected because this survey was conducted prior to participation in the LEADERS Summer Institute).

Figure 4: Cohort 2 Professional Network for Teaching Science Content

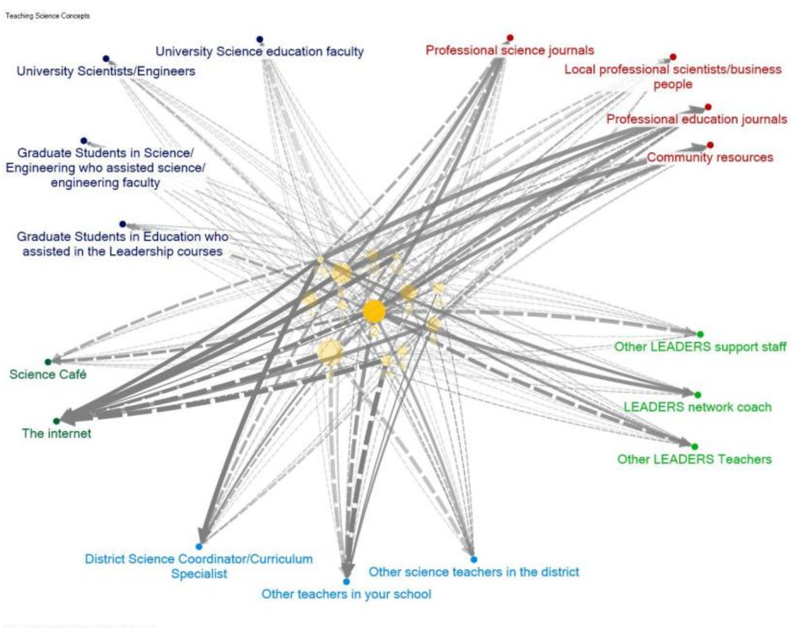


Figure 5: Cohort 2 Professional Network for PBS Pedagogy

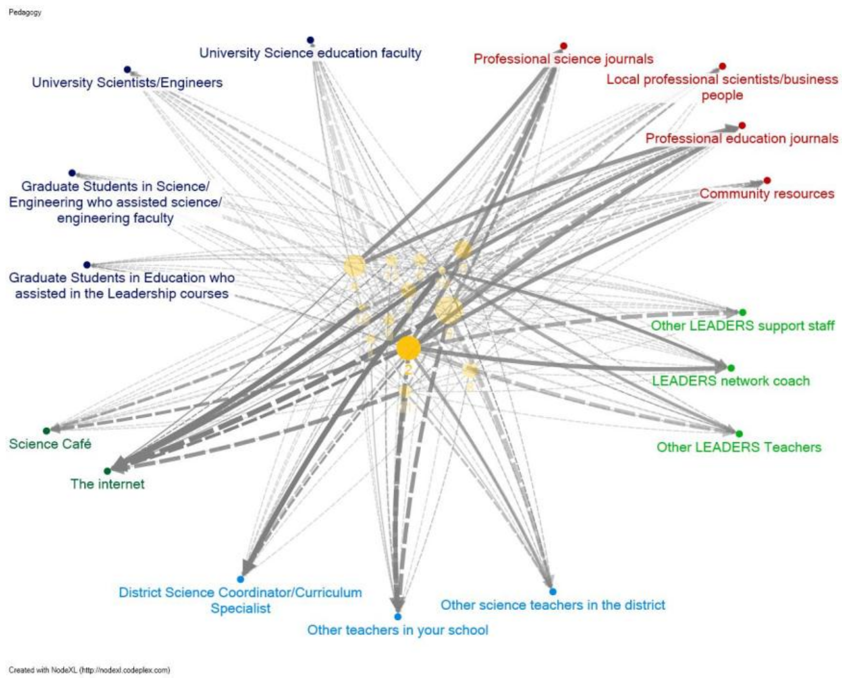
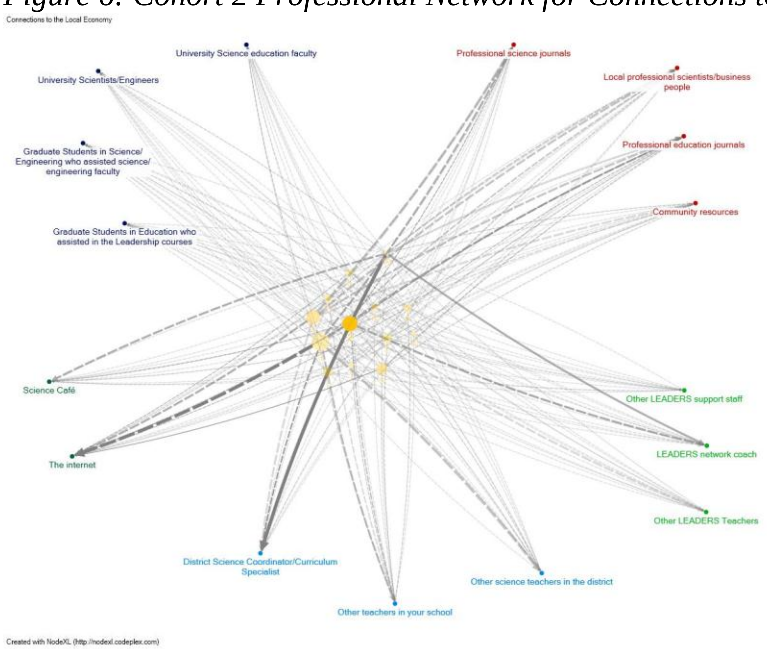


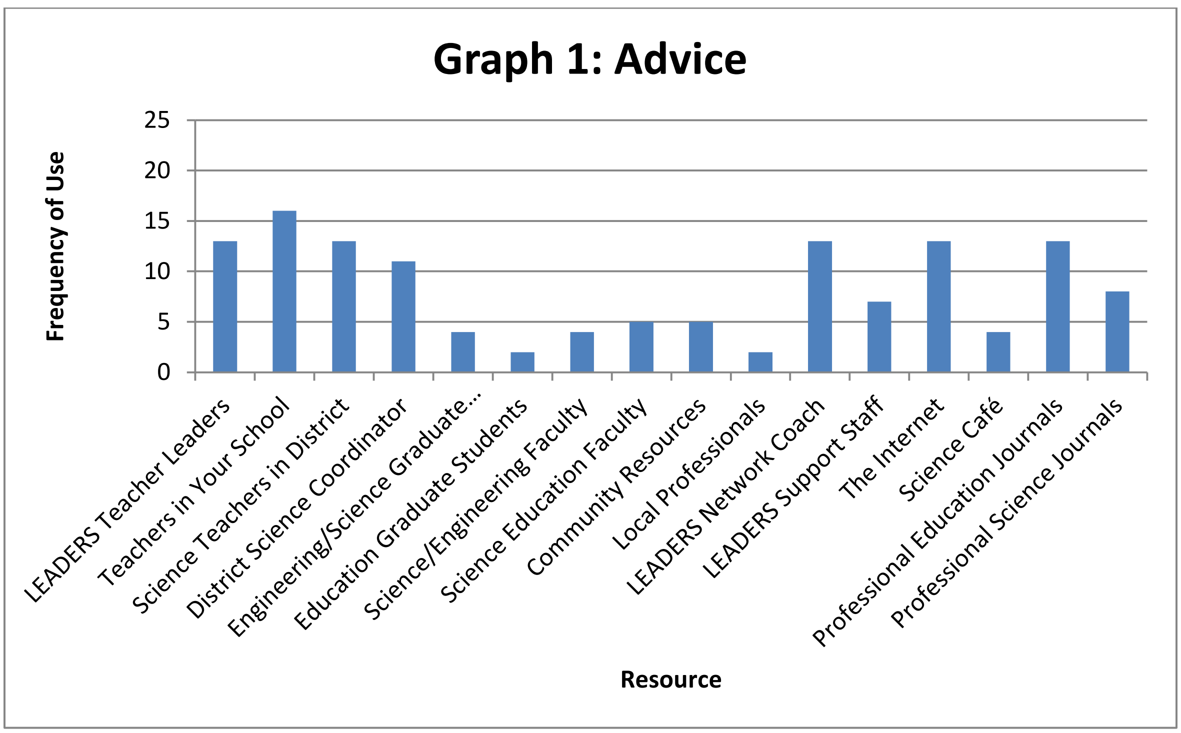
Figure 6: Cohort 2 Professional Network for Connections to the Economy

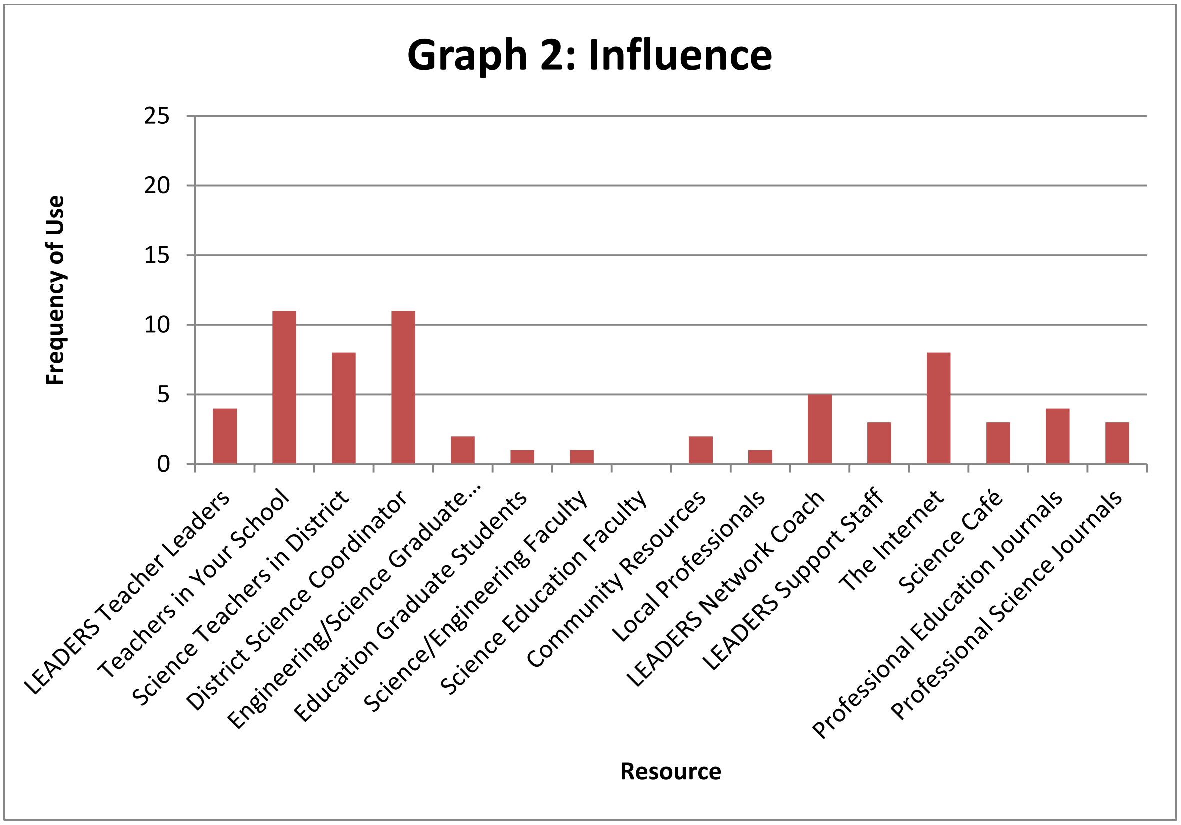


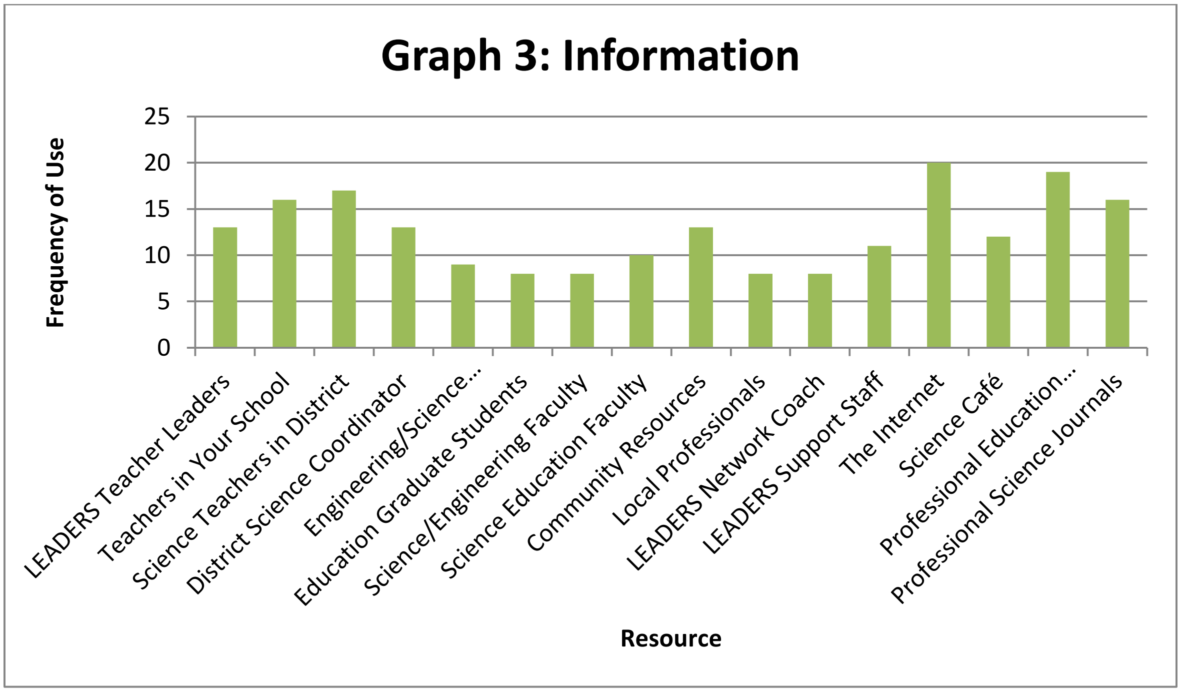
The survey also included a section that listed resources available to the TLs and asked them how they utilized the resources. The following graphs illustrate how TLs use a resource for the following purposes:

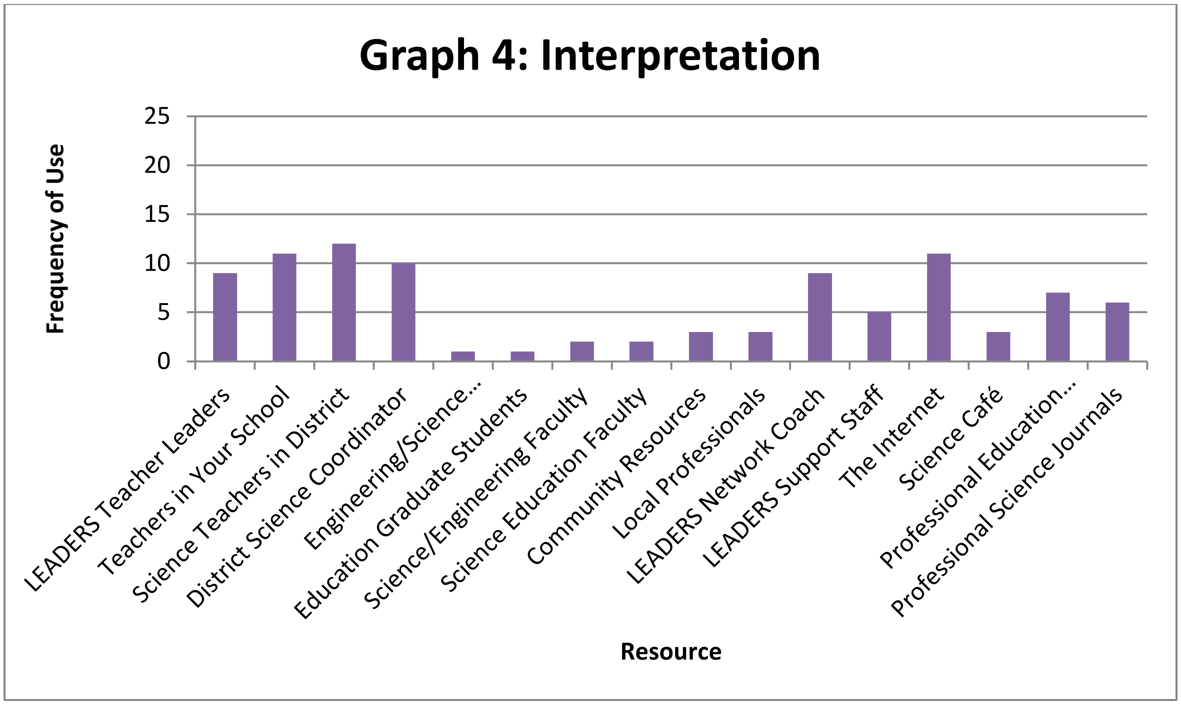
Advice: An opinion or a recommendation about something you know/use or for future purposes (What do you think of the windmill kit? Do you think this content is appropriate for my students?)
Influence: Influence over policy or procedural changes/social changes/sustainability of knowledge (e.g. Help establishing 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?)

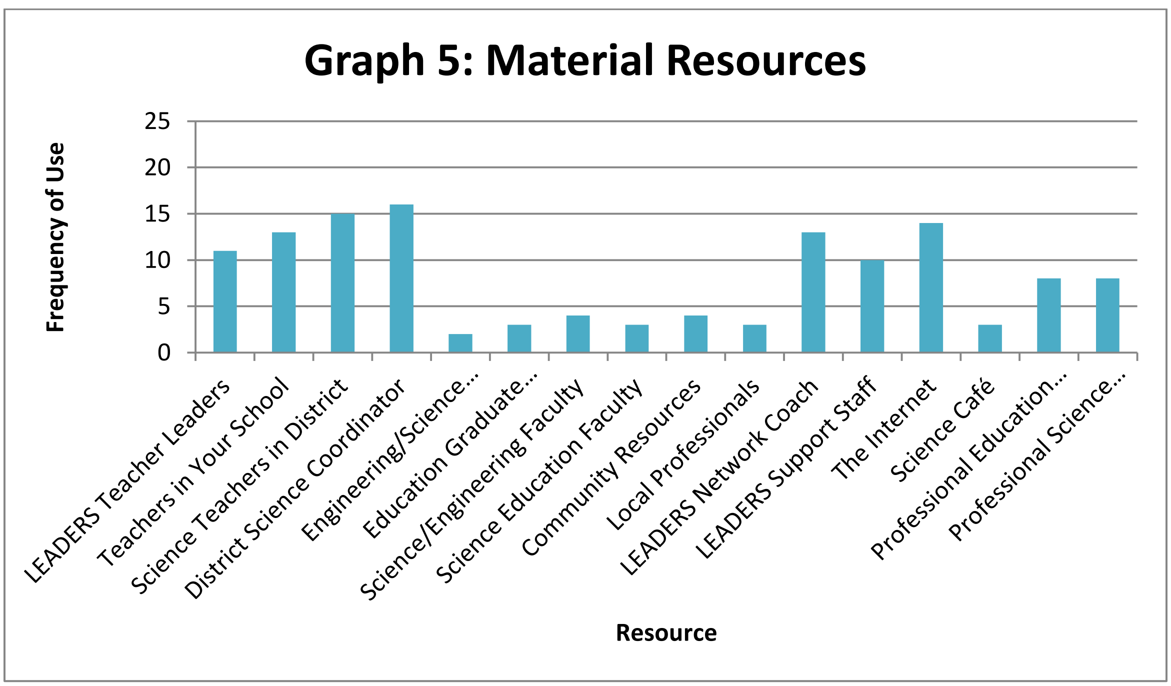
The frequency (vertical axis) indicates the number of TLs who responded they used the resource for each of the purposes. The data provided below includes both cohorts combined (n=24).

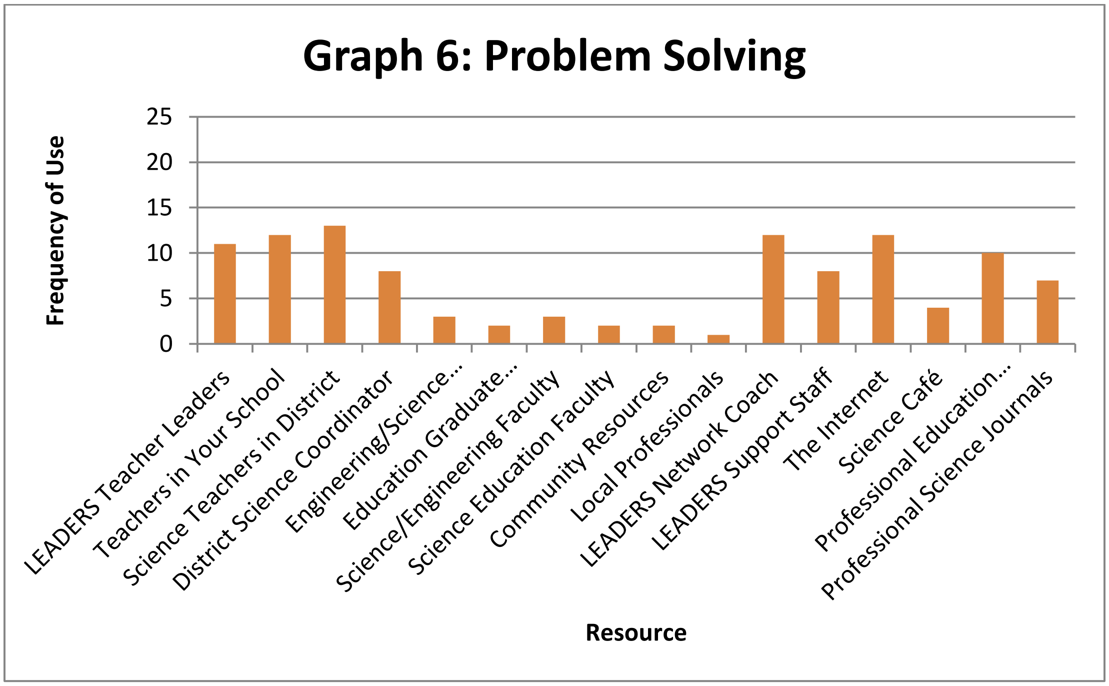


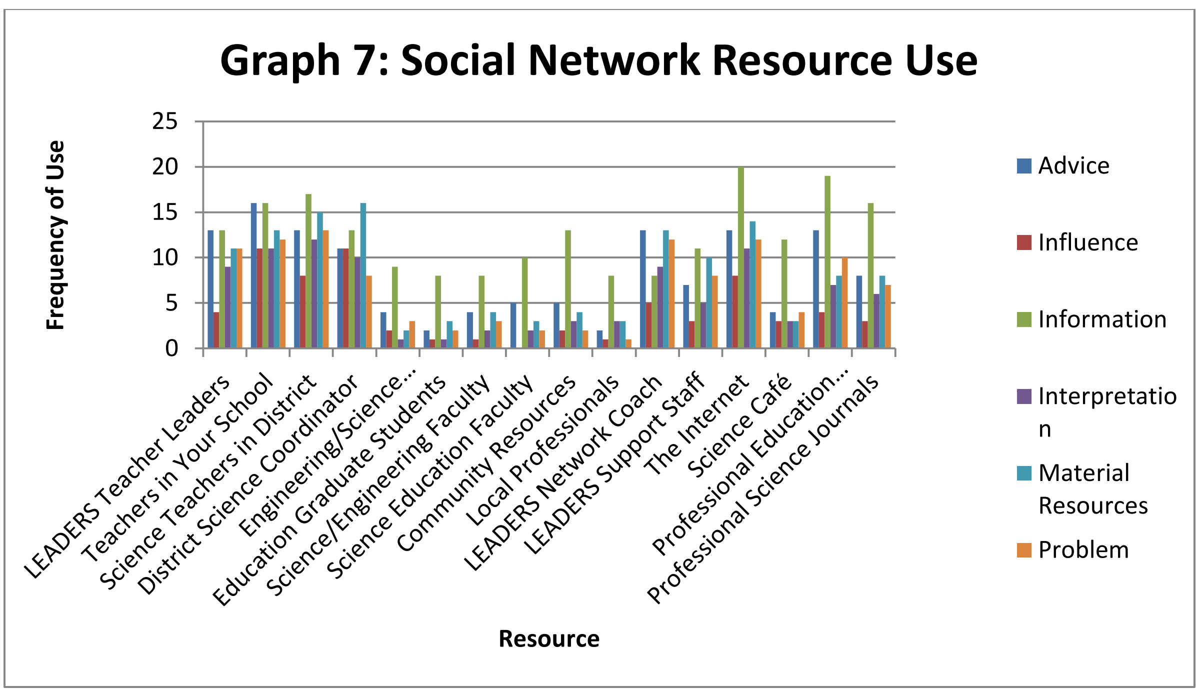

Graph 2: Influence
Frequency of Use
25
20
15
10
5
0
LEADERS Teacher Leaders
Teachers in Your School
Science Teachers in District
District Science Coordinator
Engineering/Science Graduate...
Education Graduate Students
Science/Engineering Faculty
Science Education Faculty
Community Resources
Local Professionals
LEADERS Network Coach
LEADERS Support Staff
The Internet
Science Café
Professional Education Journals
Professional Science Journals
Resource


Graph 3: Information
Frequency of Use
25
20
15
10
5
0
LEADERS Teacher Leaders
Teachers in Your School
Science Teachers in District
District Science Coordinator
Engineering/Science...
Education Graduate Students
Science/Engineering Faculty
Science Education Faculty
Community Resources
Local Professionals
LEADERS Network Coach
LEADERS Support Staff
The Internet
Science Café
Professional Education...
Professional Science Journals
Resource


Graph 4: Interpretation
Frequency of Use
25
20
15
10
5
0
LEADERS Teacher Leaders
Teachers in Your School
Science Teachers in District
District Science Coordinator
Engineering/Science...
Education Graduate Students
Science/Engineering Faculty
Science Education Faculty
Community Resources
Local Professionals
LEADERS Network Coach
LEADERS Support Staff
The Internet
Science Café
Professional Education...
Professional Science Journals
Resource


Graph 5: Material Resources
Frequency of Use
25
20
15
10
5
0
LEADERS Teacher Leaders
Teachers in Your School
Science Teachers in District
District Science Coordinator
Engineering/Science...
Education Graduate...
Science/Engineering Faculty
Science Education Faculty
Community Resources
Local Professionals
LEADERS Network Coach
LEADERS Support Staff
The Internet
Science Café
Professional Education...
Professional Science...
Resource


Graph 6: Problem Solving
Frequency of Use
25
20
15
10
5
0
LEADERS Teacher Leaders
Teachers in Your School
Science Teachers in District
District Science Coordinator
Engineering/Science…
Education Graduate…
Science/Engineering Faculty
Science Education Faculty
Community Resources
Local Professionals
LEADERS Network Coach
LEADERS Support Staff
The Internet
Science Café
Professional Education…
Professional Science Journals
Resource


Graph 7: Social Network Resource Use
Frequency of Use
25
20
15
10
5
0
LEADERS Teacher Leaders
Teachers in Your School
Science Teachers in District
District Science Coordinator
Engineering/Science…
Education Graduate Students
Science/Engineering Faculty
Science Education Faculty
Community Resources
Local Professionals
LEADERS Network Coach
LEADERS Support Staff
The Internet
Science Café
Professional Education…
Professional Science Journals
Resource
Advice
Influence
Information
Interpretation
Material Resources
Problem

In general, resources are used most frequently for the purposes of attaining information. The second most frequent use overall is to get advice. However, certain resources designed for specific purposes differ from the overall pattern. For example, the district science coordinator is most frequently consulted for material resources and the LEADERS network coach for materials as well as for assistance in problem solving.

J. Summer Institute

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.

During the 2011 Summer Institute, participants were enrolled in four graduate level courses: Earth Technologies, Biofuels, Leadership II (Assessment), and Climate Change (pretest/posttest scores for this course have not been made available to the evaluators and so will not be included in this report). Out of a possible 29 points on the Earth Technologies pretest, the TLs had a mean score of 13.09 with a standard deviation of 1.16. On the posttest, the mean score rose to 17.64 (standard deviation 0.99) resulting in a large effect size of 3.91. A paired sample t test showed statistically significant gains in content knowledge ($p = 0.001$).

The Biofuels pretest mean score was 12.42 on a 30 point scale. The standard deviation showed a large range of scores (4.42). TLs realized a large gain in content knowledge as evidenced on the posttest with a mean score of 28.09 and a standard deviation of 1.30. The smaller standard deviation shows that the TLs scored much closer together on the posttest than they did on the pretest. The effect size was large—3.54.

The Leadership/Assessment pretest and posttest examined knowledge of the use of assessment to improve teaching and to make instructional decisions based upon student feedback on assessments. The total possible points were 35. TLs achieved a mean score of 15.18 on the pretest (standard deviation of 8.19—so the scores were quite spread out). On the posttest, TL mean score was 27 with a standard deviation of 5.19 indicating that not only did the TLs perform better on the posttest but they also narrowed the range of their scores. They realized a large effect size (4.78) and had statistically significant gains ($p = 0.0002$).

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

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

- 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 average or above range with one courses receiving all “very good” scores.

III. District Science Teachers

Teachers from our randomly selected treatment and control groups were asked to complete several surveys in the fall—renewable energy content, STIPS, and STEBI. Response rates this year were similar to the previous year (although slightly lower for the Toledo Catholic Schools) and are provided in Table 11. A total of 121 teachers completed at least one the surveys: 63 from the treatment schools and 58 from the control schools.

During the district teacher focus group interviews we asked what might be done to attain a higher response rate. The teachers felt that identification by grade and school made it easy for administration to determine who made responses. Next year we will ask respondents to select from a group of schools (divided by treatment and control within their district) and their grade level. Other suggestions included that it was easy for teachers to ignore the emails sent to remind them to participate.

*Table 11: Response rates of district teachers**

	Toledo Public Schools					Toledo Catholic Schools				
Grade	Total	Responded		Resp. Rate		Total	Responded		Resp. Rate	
		2010	2011	2010	**2011**		2010	2011	2010	**2011**
Elem	116	15	16	13%	**14%**	152	66	58	43%	**38%**
Middle	43	12	16	28%	**37%**					
High School	53	19	15	36%	**28%**	42	19	16	45%	**38%**
Total	212	46	47	22%	**22%**	194	85	74	43%	**38%**

**This table represents the total number of teachers who logged into the system; not all teachers completed all three surveys.*

A. Content Tests

Treatment and control teachers were compared using an independent sample t-test to determine whether the treatment teachers have gained statistically significantly more renewable energy content over the past year. Sixty-five control and 49 treatment teachers completed the test resulting in a total of 114 teachers (first Levene's Test was first performed to determine equality of variances—variances were not equivalent; p = 0.01). A t-test assuming unequal variances was performed to compare mean scores. Scores on the 37 item test ranged from 0 to 32. The t-test for independent samples showed the groups to be equal on the content test suggesting that no significant gains in content has occurred.

Table 12: Comparison of Treatment and Control District Teachers

t-Test: Two-Sample Assuming Unequal Variances		
	Control	*Treatment*
Mean	21.75	21.27
Variance	63.75	33.32
Observations	65.00	49.00
Hypothesized Mean Difference	0.00	
df	112.00	
t Stat	0.38	
P(T<=t) one-tail	0.35	
t Critical one-tail	1.66	
P(T<=t) two-tail	0.71	
t Critical two-tail	1.98	

Performance on the test was low—57% for treatment teachers and 59% for control. While last year's analysis showed the test to be reliable, it's validity is in question as, while it covers basics of renewable energy and was developed by the project faculty, it does not necessarily match *what the TLs are teaching to their teachers.* Prior to the administration of a district teacher content test for Year 4, it is recommended that the TLs review to provide evidence of content validity.

B. Teaching Preferences and Self Efficacy

Last year district teacher responses (by district and by treatment/control group) on the STEBI and STIPS were compared by subscales to verify group equivalency and to establish a baseline. Control and treatment school teachers were equal on all measures as were teachers between districts. The surveys were repeated fall 2011 to determine whether the teachers in the treatment schools changed on the scales and, if so, whether the change was statistically significantly different from the control schools.

There were 112 respondents on the Personal Beliefs scale of the STEBI (3 of which were dropped due to extreme score; outliers)—63 from control schools and 49 from treatment schools. The teachers from the treatment schools scored statistically significantly higher on the Personal Beliefs scale indicating that they have more confidence in their ability to provide quality science instruction to their students than the teachers from the control schools. There was no statistical difference in mean scores on the Outcome Expectancy scale—the expectancy that quality science instruction will culminate in greater student learning. Results from the t-tests are provided in Table 13.

Table 13: District Teacher STEBI Scale Score Comparison

STEBI Personal Beliefs			STEBI Outcome Expectancy		
	control	*treatment*		*Control*	*Treatment*
Mean	31.7227	34.22163	Mean	17.04662	16.81449
Variance	63.35008	50.07421	Variance	26.73884	29.3703
Observations	63	49	Observations	65	49
Pooled Variance	57.55698		Pooled Variance	27.8666	
Hypothesized Mean Difference	0		Hypothesized Mean Difference	0	
df	110		df	112	
t Stat	-1.72928		t Stat	0.232425	
P(T<=t) one-tail	0.043282		P(T<=t) one-tail	0.408316	
t Critical one-tail	1.658824		t Critical one-tail	1.658573	

As with the previous year, teachers scored slightly higher than the expected mean on the Personal Beliefs scale and slightly lower than the expected mean on the Outcome Expectancy Scale indicating that they feel there are other factors beyond quality instruction that contribute to the degree of learning a student might attain.

Similar to last year, teachers in both groups scored above the expected mean in their preference for inquiry-based instruction and slightly below the expected mean for non-inquiry-based instruction on the STIPS. The ratio of preference for inquiry versus non-inquiry instructional practices was nearly equivalent (no statistically significant differences) between groups with the treatment preferring inquiry at a 1.36:1 ratio and control teachers at a 1.32:1 ratio.

IV. Student Data

Students in the district treatment and control schools are assessed on three measures: (1) Ohio Achievement Test in Science; (2) Student knowledge of renewable energy content and area commercial activity; and (3) Student attitudes towards science and interest in pursuing a science-related career. Baseline data for student knowledge of renewable energy content and area commercial activity were collected fall 2011 and a posttest was administered in late May 2012. Baseline scores are provided but the posttest is still being recorded and analyzed and will be presented in the 2013 annual report.

A. Ohio Achievement Test in Science

Because the Toledo Catholic Diocese does not require their students take the Ohio Achievement Tests, information on this measure will be provided for TPS only. Passing rates for the 2011 science tests were compared between treatment and control schools per grade. A Chi Square test of Independence was performed on 2010 student passing rates to verify group equivalency. Results indicated equivalent performance on the 2010 tests at each grade level (p =

0.98). It is important to remember that the results below occurred during the first year of the LEADERS TL PD implementation.

Table 14: 2011 TPS Ohio Achievement Test in Science Passing Rates

Treatment Schools	Total Students	Number Passing	% Passing
Total 5th grade	410	180	0.44
Total 8th grade	979	291	0.30
Total HS	625	394	0.63
Control Schools			
Total 5th grade	345	165	0.48
Total 8th grade	685	214	0.31
Total HS	558	413	0.74

A Chi Square test of Independence was performed to compare actual (treatment %) with expected (control %). No statistically significant differences were observed in passing rates between the two groups of students ($\chi2 = 0.02$).

B. Student Attitudes Towards Science

Student interest in science and science-related careers was 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*. This instrument was developed for secondary school students and has a reliability index of 0.88. It was based upon an adaptation of 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. Adaptations of the survey were made for grades3-4 and 5-6. The survey as designed was given to grades 7-9.

2011 responses are reported here as they were analyzed during that summer, part of this reporting period. The 2011-12 prestests were administered in fall but the posttests have not yet been recorded. That data will be included in the next reporting cycle.

The sample consisted of 3,963 students—2,031 from grades 7-9, 1,540 from grades 5-6, and 392 from grades 3-4. The survey for the 3rd and 4th graders showed that the treatment and control groups are not equivalent. Control students scored a mean of 3.10 and treatment a mean of 2.43 ($t = 7.35$ and $p < 0.001$). This was unexpected as the schools were selected randomly; however, not all schools completed the surveys spring 2011 and sample sizes were not equal (treatment = 186 and control = 205. In general, the students from both groups agreed with most of the items.

The 5-6 grade survey had a Cronbach alpha reliability rating of 0.71. There was no statistically significant difference between treatment and control groups at baseline (in fact the mean scores were identical at 5.108). Using Rasch modeling, we were able to determine which items the students found the easiest to agree with and which were the most difficult. The fifth and sixth graders had found it easiest to agree with “I like to read books about science” and “I’d like to have a job that involves science.” They found it most difficult to agree with “It is important to protect our environment” and “using renewable energy sources is an important part of protecting our environment” both of which focus on renewable energy science. Since this was administered last spring, it is not surprising the students did not know enough about the topic to agree with it and verifies that a project such as LEADERS that links renewable energy science with school science curriculum is needed.

Treatment and controls groups were equivalent on the attitude survey administered last spring (mean of treatment = 5.16; mean of control = 5.15; $p = 0.68$). There were 1,071 students in the treatment group and 952 in the control (variances were unequal so a t test assuming unequal variances was used to verify group equivalency). The items the students most frequently agreed with were “people with good social skills tend to become scientists” and “I might consider a career that involves science”. The items the students agreed with the least were “it is important to protect our environment” and “using renewable energy sources is an important part of protecting our environment”—identical to the items the 5th and 6th grade students had difficulty agreeing with.

All of the surveys were based on an average score of 2.5 so at each grade level the students illustrated a positive attitude towards science both from their personal perspective (I like science, I might consider a career that involves science) and from the perspective of its value to society.

C. Student Knowledge of Renewable Energy Science

Fall 2011 6th and 8th 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 but the results of that administration have not yet been recorded and analyzed. Comparison between treatment and control schools on renewable energy content will be include in the next annual report. We did verify group equivalency through the pretest. There were 20 possible points on the test. On the pretest, Toledo Public School student scored a mean of 6.45 (treatment) and 6.33 (control) at the 6th grade level. The standard deviations for both groups were approximately 2. For the 8th grade Toledo Public students the means were 7.21 (treatment) and 7.23 (control). The Toledo Catholic School students had means of 8.88 (6th treatment), 8.77 (6th control), 10.17 (6th treatment), and 10.54 (8th control). T test comparisons resulted in $p > 0.05$ within each district.

V. The Partnership

During the past year the Network Coach worked to engage business and industry partners for the project. We are currently in the process of conducting brief interviews with these identified partners and will report our findings in the next reporting cycle.

VI. Summary

The project continues to show gains in the area of Teacher Leader development. 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 prescribe in the project. The mastery of PBS continues to be elusive although participating district teachers are now gaining in their own confidence that they can provide quality science instruction.

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APPENDIX

LEADERS Teacher Leader Network Analysis Survey

The purpose of this survey is to better understand the interactions that took place in your role as a teacher leader. Although your name is required, it will not be linked to any results. Data collected will be summarized and reported as group findings.

Please provide your name:

Please select the responses that best match your opinion.

First, think about your role as a science teacher. How frequently do you go to the following concerning **teaching science in your classroom**?

	Select the response that best matches your level of contact				
	Never	Yearly	Quarterly	Monthly	Weekly
Other LEADERS teacher leaders					
For science content					
For PBS pedagogy					
To show connections to the local economy					
Other teachers in your school					
For science content					
For PBS pedagogy					
To show connections to the local economy					
Other science teachers in the district					
For science content					
For PBS pedagogy					
To show connections to the local economy					
District Science Coordinator/Curriculum Specialist					
For science content					
For PBS pedagogy					
To show connections to the local economy					
Graduate Students in Science/Engineering who assisted science/engineering faculty					
For science content					
For PBS pedagogy					
To show connections to the local economy					
Graduate Students in Education who assisted in the Leadership courses					
For science content					
For PBS pedagogy					
To show connections to the local economy					
University Scientists /Engineers (faculty who taught Summer Institute)					
For science content					

For PBS pedagogy					
To show connections to the local economy					
University Science education faculty (faculty who team taught with science/engineering faculty or taught the Leadership courses in the Summer Institute					
For science content					
For PBS pedagogy					
To show connections to the local economy					
Community resources such as personnel at science museums					
For science content					
For PBS pedagogy					
Local professional scientists/business people					
For science content					
For PBS pedagogy					
To show connections to the local economy					
LEADERS network coach					
For science content					
For PBS pedagogy					
To show connections to the local economy					
Other LEADERS support staff (those who coordinate or provide behind the scenes support and technical support					
For science content					
For PBS pedagogy					
To show connections to the local economy					
The internet (other than Science Café)					
For science content					
For PBS pedagogy					
To show connections to the local economy					
Science Cafe					
For science content					
For PBS pedagogy					
To show connections to the local economy					
Professional education journals					
For science content					
For PBS pedagogy					
To show connections to the local economy					
Professional science journals					
For science content					

For PBS pedagogy					
To show connections to the local economy					

Now think about your role as a Teacher Leader. How frequently do you go to the following concerning **preparing and delivering project based science professional development?**
(table above repeated)

Again, as a Teacher Leader, how frequently do you go to the following concerning **support for your role as a coach for your science education peers?**
(table above repeated)

Please indicate the nature of your interaction with the following resources using the following definitions:
User definitions:

1. **Information**: Knowledge concerning a particular situation/fact/idea (Where can I find the sample lesson plans)
2. **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?)
3. **Problem solving:** Reaching out for expertise on a problem you cannot resolve alone (How do I motivate a particular teacher?)
4. **Material resources:** Teaching supplies/teaching materials/curriculum material/classroom supplies
5. **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?)
6. **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)

Check all that apply:

	I did not use this resource	Informati on	Advic e	Proble m Solving	Material Resource s	Interpretati on	Influenc e
Other LEADERS teacher leaders							
Other teachers in your school							
Other science teachers in the district							
District Science Coordinator/Curriculu m Specialist							
Graduate Students in Science/Engineering who assisted science/engineering faculty							
Graduate Students in Education who assisted in the Leadership courses							
University Scientists /Engineers (faculty who taught Summer Institute)							
University Science education faculty (faculty who team taught with science/engineering faculty or taught the Leadership courses in the Summer Institute							
Community resources such as personnel at science museums							
Local professional scientists/business people							
LEADERS network coach							
Other LEADERS support staff (those who coordinate or provide behind the scenes support and technical support							
The internet (other than Science Café)							
Science Café							
Professional education							

journals							
Professional science journals							

Over the past year, have you recommended the following resources to others? (Note: for each item that is marked "I have not recommended", an open-ended text box will pop up asking why the resource has not been recommended).

	I have recommended this resource	**I have not recommended this resource**
Other LEADERS teacher leaders		
Other teachers in your school		
Other science teachers in the district		
District Science Coordinator/Curriculum Specialist		
Graduate Students in Science/Engineering who assisted science/engineering faculty		
Graduate Students in Education who assisted in the Leadership courses		
University Scientists /Engineers (faculty who taught Summer Institute)		
University Science education faculty (faculty who team taught with science/engineering faculty or taught the Leadership courses in the Summer Institute		
Community resources such as personnel at science museums		
Local professional scientists/business people		
LEADERS network coach		
Other LEADERS support staff (those who coordinate or provide behind the scenes support and technical support		
The internet (other than Science Café)		
Science Café		
Professional education journals		
Professional science journals		
Other LEADERS teacher leaders		

During the current school year, how often have you attended the following professional development (PD) activities *outside of LEADERS*?

	Never	Once	Twice	Three times	Four times	Five or more times
District sponsored science PD						
District sponsored pedagogy PD						
Local science or science education conferences						
Regional science or science education conferences						
National science or science education conferences						
University sponsored workshops or summer institutes						
We based tutorials or seminars						

What percent of the current year's total professional development activity was directly linked to your classroom instruction?
What percent of the current year's total professional development helped you learn new scientific inquiry techniques?
What percent of the current year's total professional development helped you implement new instructional strategies?
What percent of the current year's total professional development helped you learn new science content?
What percent of the current year's total professional development helped you learn to use new science and technology tools for the classroom?
What percent of what you have learned through the NSF LEADERS project is integrated in your classroom?
Were there other applications of what you have learned through professional development? If so, please explain: