NSF MSP LEADERS Project

Evaluation Report

Year Two

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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 September 2010 through May 2011.

Executive Summary

Evaluation efforts during Year 2 continued the collection of baseline data, provided formative evaluation for the Summer Institute and the academic year Teacher Leader follow up events, and examined growth in the teacher leaders on some metrics. A few changes occurred in the data collection timeline due to scheduling difficulties with the school districts and to changes in the implementation of the project activities. This change in the schedule, however, did not affect data integrity.

Teacher Leaders showed modest gains in the area of science teaching self-efficacy and baseline data on science teaching style preferences showed that as a group they preferred inquiry-based instructional strategies over non-inquiry based strategies (1.6 to 1 ratio). The Teacher Leaders were, however, reluctant to share control of learning responsibilities with their students. Teacher Leader leadership responsibilities did not change since last year. However, their levels of comfort in carrying out leadership responsibilities increased and particularly in the areas of designing professional development that includes energy-related content, organizing and facilitating professional development workshops, and working with science and industry partners. Finally, the Teacher Leaders felt they have gained quite a bit of knowledge and skill in the areas of project based science, working with new and experienced teachers to understand energy content, and writing energy-related curriculum.

Qualitative investigations of Teacher Leaders' beliefs and understanding of project based science revealed that while all Teacher Leaders have an orientation towards reform-based teaching; most do not have a comprehensive understanding of the essential components of successful project based science lessons/units. Their understanding is, however, more accurate than the previous year suggesting that a complete understanding of project based science is not something that results from formal training but rather is developed over time through implementation, trial and error, and working with experts who provide frequent feedback.

To examine the effectiveness of the Teacher Leaders as providers of renewable energy science professional development, attendees of the workshops (district teachers) were asked to complete a "customer feedback" form based upon adult professional development research. Overall, the district teachers felt the sessions provided them with new and interesting content and lessons that could be used in their classrooms. The feedback forms were augmented with information collected at the conclusion of the series of professional development sessions during a focus group interview. District teachers felt they learned most about solar energy, new terminology, and how to use new science equipment. They liked the daily schedules for the sessions but preferred they be offered in the fall so that they can implement them throughout the year. They also wanted the sessions to be spread out a week or two apart so that they have a chance to try out some of what they've learned before meeting again. They felt the resources they learned of during the sessions to be the most valuable part. Unintended results of the professional development sessions included the realization that their students' problem solving skills are weak and they themselves are now more likely to take risks in the classroom.

Baseline data was collected on Teacher Leaders' professional networking. Currently, the Teacher Leaders gather most support from other science teachers in their schools and from the LEADERS support staff. Informal science organizations provide them with science curriculum resources. The teacher leaders engage in very little professional development outside of LEADERS. When asked how useful the LEADERS professional development was to their teaching as opposed to other professional development they engaged in, the LEADERS activities provided nearly twice as much relevant material.

Baseline data was collected from the treatment and control school teachers on the STEBI, STIPS, and renewable energy content. Response rate was not as high as expected (22% from Toledo Public Schools; 46% from Toledo Catholic Schools). To improve Toledo Public School participation in this aspect of the evaluation, the PIs will add a representative from the Toledo Federation of Teachers union in the leadership team. Comparisons on all three measures proved the groups to be equivalent on the measures. Teachers scored slightly above the expected mean on the inquiry scale of the STIPS and slightly below the expected mean on the non-inquiry scale. Like the teacher leaders, they scored slightly higher than the expected mean in their belief that they can provide quality instruction but slightly below the expected mean in their expectation that good teaching practices will improve student learning.

Equivalency of students in the treatment and control schools was established by comparing passing rates on the Ohio Achievement tests in science (grades 5, 8, and high school). A Chi Square test of Independence was performed verifying group equivalency in achievement on the standardized tests. To verify whether the students in the two groups were equivalent in their understanding of the relevance of science and their interest in science-related careers, and to establish a baseline for growth, a project-developed attitudinal survey was administered late spring. That data will be analyzed over the summer and presented in the next annual report. Content tests, originally scheduled to be given spring 2011, were postponed to early fall 2011.

Finally, exploratory data has been collected from higher education partners (scientists and engineers) and business partners. This information has been used to better understand of how the partners view their roles in LEADERS, determine whether partners hold any misconceptions about K-12 science education, develop a standardized set of questions to ask annually to examine change in partner relationships, and to prompt the partners to think about how each might contribute to the success of the project. Both faculty and business partners expressed an eagerness to work with K-12 science education.

To date, most of the baseline and some of the comparison data has been collected. Treatment and control schools (teachers and students) have been verified to be equal on project measures. Teacher Leaders have shown gains in the area of self-efficacy, level of comfort facilitating leadership responsibilities, and obtaining the knowledge and skills to fulfill their role as teacher leaders.

I. LEADERS Evaluation Model

While implementing the evaluation plan over the past year, logistical problems arose relating to gathering data from school district teachers and students. Scheduling LEADERS data collection at times that did not conflict with school responsibilities (e.g., standardized tests and exams) or with holidays was challenging. Gaining cooperation from principals and teachers, while eventually accomplished, was an arduous task that was completed only through the collaborative efforts of the project leadership team, the school district leaders, and the evaluation team. Because more time than was anticipated was devoted to establishing a concerted effort between the evaluation team and the school districts, student content tests will not be given until fall 2011. Additionally, baseline student attitude data was collected from the control and treatment schools in the spring 2011 as opposed to fall 2010. Since the professional development workshops were not implemented until the spring, it is unlikely spring 201l student attitudes about science were affected by the project thereby not affecting baseline data. District teachers supported this conjecture indicating that what was learned this spring would be implemented in their classrooms next year.

The evaluation team also experienced difficulty determining the extent to which teacher leaders and district teachers have mastered project based science (PBS) using the Horizon Observation Protocol. While this instrument was designed to evaluate an inquiry-based science or mathematics lesson, it may not adequately assess the complexity of PBS mastery and therefore use of it alone to measure PBS may lack validity. PBS implementation can extend over several weeks and should involve a variety of instructional strategies—some of which may not be inquiry-based and some of which may simply be students conducting research on a problem. A one-day or class period observation provided little insight into the extent to which PBS is being implemented or into the teacher's understanding of PBS and how to implement it. With this in mind, the evaluation team in collaboration with the LEADERS leadership team will examine other possible, valid means by which to examine PBS mastery during years 3-5 including examination of extended lesson plans and in depth case studies of a few randomly selected teachers. The resulting measurement may be useful to other NSF funded projects using PBS.

The Context Beliefs About Science Teaching instrument (CBATS) was replaced with the Science Teacher Ideological Preference Scale (STIPS)—an instrument designed to measure science teachers' instructional practice preferences. It consists of two subscales: inquiry-based instructional strategies and non-inquiry-based strategies (Jones and Harty, 1978; Gado, 2005). Results of this survey can provide insight as to teacher willingness towards using inquiry-based instructional strategies. It is our expectation that exposure to the LEADERS professional development workshops will increase teacher preferences towards inquiry-based strategies while diminishing their preferences for non-inquiry based strategies.

Table 1 (page 7) presents only the components of the LEADERS evaluation plan that have been completed during the second year of the project. Data collected to evaluate last summer's institute were reported in the first year report and Year 2 Institute data will not be collected until July 2011 and therefore presented in the next reporting period.

II. TEACHER LEADERS (TLs)

Several quantitative instruments along with personal interviews were employed to measure change in teacher leader attitudes, confidence, and ability. Results concerning content mastery gained from the first summer institute were reported in the Year 1 evaluation report. Year 2 summer institute content mastery will be reported in the Year 3 annual report. Instruments reported here include 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 Project Based Science Teaching Questionnaire. Responses to personal interviews are also included.

A. Science Teacher Efficacy Beliefs Instrument

One measure of teacher leaders' motivation to enact change within their classrooms as well as their districts is the belief that what is done will have a positive effect. Bandura (1977) referred to this as <u>outcome expectation</u>. Coupled with outcome expectation is the confidence that the person can perform the action successfully. This is the <u>self-efficacy expectation (or personal beliefs)</u>. The Science Teacher Efficacy Beliefs Instrument (STEBI-A) was developed by Enochs and Riggs (1988) to measure both constructs in practicing teachers and the comparison of scale scores over time can be used to make assumptions about changes in science teaching self-efficacy. The five point rating scale provides an ordinal score (ranked) with a "1" indicating low outcome expectation and self-efficacy expectation and a "5" indicating a high level of each construct. 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, we utilized Rasch modeling to convert the ordinal scores to an interval scale. Earlier analyses of the STEBI using Rasch showed that the neutral option (3) did not add information to the results and confounded the adjacent response options. Prior to administering the survey spring 2011, we eliminated the "neutral" option from the original five point scale resulting in a four point scale with the following options:

Strongly disagree (1) Disagree (2) Agree (3) Strongly agree (4)

Scores from 2010 were recalibrated using the new scale by eliminating the middle or neutral option and anchoring with the standardized scale resulting from the Rasch analysis of the district teacher data (see Section III). The 2011 data was anchored the

LEADERS Revised Evaluation Model

Modifications to the plan are in bold print.

Table 1: LEADERS Year 2 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	Survey of type, number, and nature of partner relationships	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	semi-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	annually
1-5	Improved leadership skills	Survey based on Performance Expectations and Indicators for Education Leaders	Project developed	annually
1-5	Understanding and implementation of PBS	**Review of teacher leader Five E model lesson plans (rubric)**	Project developed	semi-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

same way. While TLs increased their scores on the Outcome Expectancy scale, it was not statistically significant. However, this could be due to a small sample size where the standard error is typically quite large. They did, in fact, realize a medium effect size gain (d = 0.52). Mean scores increased from 35.41 in 2010 to 46.75 in 2011 indicating that some positive change in their expectations that high quality instruction can improve student learning took place (t = 1.64; p = 0.13).A comparison of scores on the Personal Beliefs scale between the two years showed that the TLs scored on average well above the expected mean of 25 (2010 = 46.15; 2011 = 47.89). The increase in 2011 was not statistically significant and showed a small effect size gain (d = 0.2). In both years, the TLs had confidence in their ability to deliver meaningful, high quality science instruction. Overall, participation has had some effect on the TLs' self-efficacy beliefs concerning science instruction.

B. STIPS

The STIPS provides a measure of science teacher preferences for inquiry based and more traditional (non-inquiry based) instructional strategies and procedures. This measure was added to the LEADERS evaluation plan spring 2011 because the evaluation team felt analysis of scores on this instrument might better reflect the goals of the LEADERS professional development sessions (both the TL Summer Institute and the TL led district professional development) than the CBATS. Data collected this year will serve as baseline and does add to the "picture" of the TLs. A copy of the STIPS can be found in the Appendix.

As with the STEBI, the STIPS scores were converted to an interval scale using Rasch modeling and recalibrated using district teacher responses as anchors. The expected mean on each of the STIPS scales was 25. Overall, the 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). There was a wide range of scores between the highest and lowest scoring TL in both categories (see Table 2) and the inquiry scale scores in particular had a quite large standard deviation indicating that there is a great deal of variation in the TL responses to this scale. This suggests that some TLs embrace inquiry based instruction to a much greater extent than others:

Table 2: TL STIPS Descriptive Data

	N	Minimum	Maximum	Mean	Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Statistic
STIPSI2011	12	18.79	49.48	32.3958	9.54323
STIPSNI2011	12	14.24	23.68	20.4017	2.48025

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." Two other items that TLs found difficult to agree with were: (1) Students should have a major role in making decisions about what are the best means for learning the concepts in the material being studied; and (2) To learn a scientific law or principle, students should be provided exemplifying instances from which they infer it without the teacher giving it. All three of these items center on giving students more control over how they learn.

The items on the non-inquiry scale were clustered closely together as far as how frequently TLs agreed with them. However, the item they most frequently *agreed* with runs contrary to the nature of science: “Science should be taught as a discipline of conclusive and authoritative information that has been verified beyond dispute.” Data reported in Year 3 will be compared with this baseline data to determine whether project participation has increased their preference for inquiry-based instruction and decreased their preference for non-inquiry based strategies. It is recommended that the issues of granting students more control over how they learn be explored by the leadership team and incorporated into the project.

C. LEADERS Leadership Inventory (LLI)

The LLI is based upon a teacher leadership survey developed by the Georgia Partnership for Reform in Science and Mathematics (PRISM) and funded by the National Science Foundation. The LLI is designed to first determine the amount of leadership responsibility the TLs have for specific duties associated with teacher leadership and the LEADERS project and then explore how comfortable the TLs were engaging in these same activities. The LLI also contains a Skills and Knowledge scale to determine whether the TLs perceive themselves to have what is necessary to perform many of the leadership responsibilities associated with the project. All three scales use responses ranked 1 through 5 with a 5 indicating more positive responses. Based upon Rasch analysis of combined baseline and follow up data, as well as the small sample size (n = 12), it was determined that a parametric analysis of the data was not appropriate nor would it lead to valid conclusions. Instead, frequencies of responses over 3 (the expected “average” or median score per item) were calculated and compared to determine whether the TLs reported more responsibility and more confidence carrying out leadership responsibilities. There was very little difference between the first and second year total responses to **leadership responsibilities** (increased from 68 to 69 rankings of 4 or 5 on the 5 point scale). While some TLs scored much higher the second year, others actually scored lower. This is most likely due to changes in the districts that have shifted some TLs to different schools and placements.

Gains in perceived levels of **comfort engaging in leadership activities** increased dramatically. During Year 1, only one TL responded above average comfort levels on only one item. The responses above the average for Year 2, however, showed the TLs have matured in their confidence to lead (107 responses to the 11 items on this scale at the above average rating). While the TLs indicated increased comfort levels in all activities, they showed particularly high gains in the following areas (over 10 TLs increased their ranking from “at or below average” to “above average”):

- Designing customized professional learning opportunities and programs for other science educators.
- Providing energy-related content support to other science educators.
- Organizing and facilitating professional learning communities for science educators.
- Being an advocate for science activities and strategies.
- Working with scientists and industry partners.

A final section of the leadership survey explored teacher leaders' perceived **skill and knowledge levels** pertaining to a variety of duties and responsibilities associated with the LEADERS project. This 14-item section began with "I have the knowledge and skills to . . ." and was followed by a responsibility or duty such as "discuss education-related policies with policy makers (e.g., superintendents, government officials, etc.)". Respondents indicated their level of agreement with each statement. Areas that showed the most gain in perceived skill and knowledge levels were (again, over 10 TLs increased their ranking):

- I am knowledgeable about project-based science.
- I have the knowledge and skills to help new teachers understand and teach about energy issues.
- I have the knowledge and skills to write curriculum about energy issues.
- I have the knowledge and skills to help experienced teachers understand and teach about energy issues.

Findings from the LLI provide self-reported data as to TLs' growing confidence in their ability to be leaders and to provide effective professional development to their fellow teachers.

D. Teacher Beliefs Interview (TBI)

TLs were interviewed during the fall semester 2010 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 teachers' responses to be categorized into one of five orientation categories. These categories ranged from traditional to reform-based. They provided a deeper understanding of each teacher's thoughts and a method of triangulation as they relate closely to the five levels included in the Horizon's Inside the Classroom Observation Instrument used to score initial TL observations in last year's report.

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.

TLs' responses to the TBI were recorded and transcribed. Three coders rated responses separately and discussed discrepancies until a code could be agreed upon. Results from this analysis are presented in Table 3.

Table 3: Coded Responses to the Teacher Beliefs Interview

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

*pseudonyms

None of the TLs appeared to have traditional orientations. Only two demonstrate a tendency toward instructive beliefs that may hinder their ability and/or willingness to adopt reform-based methods. The majority of teachers have orientations that are largely conducive to understanding and adopting a PBS approach. Three teachers demonstrated orientations toward the ideal of "reform-based". The remaining eight fell largely into the "transitional" orientation category. This category indicates that teachers have some of the characteristics necessary to move toward a more reform-based orientation but may need scaffolding and guidance to do so. Information gathered from this interview will be useful to the LEADERS implementation team as they work with TLs in the upcoming Summer Institute. This interview protocol could also be a useful tool in the selection of TLs for cohort 2.

E. PBS Understanding

Each TL was asked to provide a definition of PBS on a written survey at the end of the summer institute and during the PBS interviews that took place during spring semester 2011. These definitions 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. Definitions from the PBS survey and PBS interview along with the example of PBS TLs provided were given one point for each feature mentioned. Using this method a maximum score of eight was possible. Mean scores on the survey and interview were 1.5 and 2.67 respectively. No individual teacher mentioned all eight characteristics of PBS and the highest combined score (survey and interview) was “6” (two TLs). These two teachers mentioned all features except cognitive tools and assessment during their interviews. Otherwise, definitions were brief and superficial. Two teachers gave definitions that did not contain any of the core features of PBS and another only mentioned driving questions. The rest of the definitions were brief and superficial demonstrating that while these teachers believe they understand PBS, in actuality they do not have a firm grasp of what PBS is.

Table 4: Frequency Count of PBS Features Included in Teacher Definitions

Feature	**Survey**[1]	**Interview Definition**[2]
Driving Question	3	8
Learner Product	0	5
Investigation	0	6
Assessment	0	0
Cognitive Tools	0	0
Collaboration	4	4
Scaffolding	1	3
Extended Length	0	7
Student-driven	3	12
Real World	2	4

[1] Maximum score = 8
[2] Maximum score = 12

The eight definitions provided on the PBS survey included only three of the features agreed upon by experts, collaboration, driving questions, and scaffolding. Six features were mentioned during PBS interview definitions. None of the responses mentioned the use of assessment or cognitive tools. In addition to the eight features agreed upon by experts, teacher leaders mentioned two others. Several TLs mentioned that PBS should relate content to the real world and/or students’ experiences. Student choice and control was a feature that was mentioned several times on the survey but was mentioned by all teachers during their interview. It is interesting that when completing the inquiry based instruction scale for the STIPS, the TLs had difficulty agreeing to strategies that gave students more control. So while they understand it is an essential component for PBS, they are reluctant to implement it. For the majority, this feature was a major focus of their interview definition. Below are some examples:

> I'd say that [PBS] is a long-term project that has some kind of an artifact at the end. You have to have a driving question that is propelling the unit and it’s more student-driven with students coming up with a lot of the design of the project. Students are involved in the entire process (PBS Interview 2-28-2011).

> [PBS] is an approach to teaching science that centers around a driving question that covers an entire unit of study. It’s more authentic and real world with a question that kids care about and get involved in and that question drives all the rest of the learning. Kids are generating

> with the question, kids are creating artifacts to show what they know (PBS Interview 3-11-2011).

This response was the least related to core features:

> I would say PBS is something you're already doing but maybe not doing as often and once you do it, it's student based, it's engaging the student and it's letting them direct you where they need to go in their learning and their development to get them to have 21st century skills (PBS Interview 3-4-11).

This definition represents one of the most detailed:

> I would tell them that [PBS] is learning the science content through doing experiments—that the experiments and the projects are kind of the main course and not the dessert when you finish it up at the end. I would also want to say that all the projects are not stand-alone projects but they're united under a theme, which is a driving question. I would also say that the students should have input on the questions that are going to be answered and the projects they are going to do and that there should definitely be a conclusion. Even though the projects are fun and the projects are the meat of it you can't just do the project and move on. There definitely has to be sense making. There has to be time for the students to apply what they learned, apply what they did in the experiments to the concepts they are expected to learn and hopefully they'll do that to their peers and with their peers (PBS Interview 3-4-11).

Overall, the definitions of PBS teachers reported did not demonstrate a firm understanding of the core features of PBS. In fact, only half of the TLs mentioned that the approach had anything to do with inquiry or scientific investigation. Fewer than half mentioned that students should produce a tangible product or collaborate with peers, even at a surface level. A review of the key features of PBS should be included in the 2011 Summer Institute and frequent emphasis of these features should occur during the academic year.

F. PBS Implementation Interviews

We interviewed TLs about their implementation of PBS in February and March 2011. TLs were asked if they had implemented what they would call a "formal PBS unit" in their classroom during the current academic year. All responded that they had in some form; most brought up multiple examples. One TL was a short-term sub in a 5^{th} grade classroom during the unit implemented and expressed that it was difficult to implement PBS in that environment. None of the other TLs indicated any problems incorporating the unit into their classrooms. All teachers were asked to choose the unit they believed was the best representation of PBS and were asked to answer following questions about it:

- How many days/classes did the unit span?
- Did the unit have a driving question? If so, what was it?
- Did students generate their own questions based on the driving questions? If so, what were they?
- How did students collaborate or work in groups during this unit?
- Did students collect and analyze data?
- If there was an experiment done, did students design the procedures they used?
- Was technology incorporated into this unit?

- Did students produce a tangible product or project?
- What were your learning goals for this unit?
- What kinds of assessments did you use to gauge student understanding?
- How well do you believe this unit conformed to the ideas about PBS you learned during the summer institute? In what ways was it similar and/or different from what you learned?
- If one of the teachers in your PD asked you to describe what PBS was, what would you tell them?

This example of the most PBS-like activity given by each teacher was summarized and analyzed in relation to core features of PBS, scientific investigation, and project goals. Table 5 summarizes this analysis (page 16).

The first question in Table 5 provides scores for the driving questions reported by the TLs. The textbook used in the LEADERS Summer Institute PBS Course (Krajcik & Czerniak, 2007) described four features of PBS driving questions. These features included that a PBS driving question was one that: (a) related to science content standards, (b) connected to real-world issues, (c) was relevant to students lives, and (d) allowed room for students to pursue solutions over time. Only two teachers described units that were driven by PBS-like driving questions. A third teacher provided a question that addressed two of these four features and was therefore scored "somewhat".

The next four questions addressed the content and process learning goals of the units described by the TLs. These were derived from the project goals. All TLs' units had goals for science process skills on some level. More than half had science content goals but three had described lessons that were unrelated to science content.

The next six questions related to cycles of scientific investigation. Only four teachers reported units that contained a scientific investigation that spanned multiple days. Of these four, two appeared to engage students in all parts of an investigative cycle. The other two provided examples of lessons that were more teacher-directed and supplied students with the questions and methods they would use in investigations. The remaining eight teacher leaders discussed lessons that were largely removed from the process of scientific investigation.

The final two questions used to analyze lesson plans focused on central features of PBS—use of technology as a method of collecting and manipulating data and student production of a tangible product. Only three TLs described incorporating technology into their unit in a way that allowed students to collect and manipulate empirical data. Five others described using technology in a way that may have allowed students these opportunities or in way that somewhat addressed these ideas. Only one TL described student creation of a product with definite real-world value. Five others described the production of a tangible product but one that did not necessarily have value outside of their classroom.

Some of the TLs stated that they did not think their project was a good example of PBS while others felt theirs was. Additionally, some teachers felt they had done something new in their classrooms while other did not think they had. The final two rows in Table 5 provide each teacher's response to these questions.

Table 5: Preliminary Analysis of LEADERS PBS Implementation Descriptions

Did the teacher's discussion of their PBS Unit provide evidence of:	**Sheri Jacobs**	**Claudia Farley**	**Irene Hobart**	**Heidi Conklin**	**Travis Wright**	**Deborah Samford**	**Rhonda Lipsey**	**Amanda Emerson**	**Mary Rhode**	**Emily Bolen**	**Lynne Brandt**	**Beverly Magness**
A PBS-like driving question[1]?	No	No	No	No	No	No	Yes	No	No	Yes	Somewhat	No
A connection to science process skills?	Yes	Somewhat	Yes	Somewhat	Yes	Somewhat	Yes	Somewhat	No	Yes	Yes	Somewhat
An explicit connection to scientific concepts or content?	Somewhat	No	Yes	No	Yes	Somewhat	Yes	Yes	Yes	Yes	Yes	No
An explicit connection to renewable energies concepts or content?	No	No	Somewhat	No	Somewhat	No	Yes	No	No	Yes	Yes	No
An explicit connection to the economy of the Great Lakes Region?	No	No	No	No	No	No	Somewhat	No	No	Somewhat	No	No
A scientific investigation[2] that extended over multiple days?	Somewhat	No	Yes	No	Yes	No	Yes	Somewhat	Somewhat	Somewhat	Yes	No
An opportunity for students to generate research question?	No	No	No	No	Somewhat	No	Yes	Somewhat	No	Somewhat	Yes	Somewhat
An opportunity for students to design and plan an investigation?	No	No	No	No	Somewhat	No	Yes	Somewhat	No	Somewhat	Somewhat	No
An opportunity for students to collect data through direct observation[3]?	Somewhat	No	Yes	No	Yes	No	Yes	No	No	Somewhat	Yes	No
An opportunity for students to analyze, interpret and/or model data?	Somewhat	No	Yes	No	Yes	No	Yes	No	No	Yes	Yes	No
An opportunity to draw conclusions and/or communicate findings?	Somewhat	No	Yes	No	Yes	No	Yes	Somewhat	No	Yes	Yes	Somewhat
An opportunity to use technology in the process of collecting or analyzing data?	No	No	Yes	Somewhat	Yes	Somewhat	Yes	No	Somewhat	Somewhat	No	Somewhat
Was a product or project that had real-world value created?	No	No	No	No	No	No	Somewhat	Somewhat	Somewhat	Yes	Somewhat	Somewhat
Did they believe this was true PBS?	Yes	No	Yes	Yes	Yes	No	Yes	No	No	No	No	No
Was this different from normal teaching methods?	S	Yes	S	No	S	No	S	No	Yes	S	S	Yes

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.

The units described by the teacher leaders varied in the degree to which they address core features of PBS and project goals. While a few of the teacher leaders provided examples of units that aligned well with desired features, the vast majority did not. Ten teachers did not discuss PBS-like driving questions, eight provided examples of units that were unrelated to scientific investigation, only one provided an example of a tangible product with real-world value, and none discussed learning goals related to the renewable energies industry of the Great Lakes Region. **These broad trends demonstrate that the teachers may need more guidance and/or instruction in both content and pedagogy related areas to achieve the goals of this project.**

G. Renewable Energy Workshops (PD)

The 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 & 7; (2) Toledo Catholic Schools (TCS) grades 3 & 5; (3) TCS grades 6 & 7; and (4) TCS and TPS combined grade 9 physical science. At the conclusion of each PD session, 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 as well as upon hallmarks of the Leadership course delivered in the 2010 Summer Institute (see Appendix for a copy). Information gathered from this form was used primarily for formative evaluation to allow the TLs to get an objective grasp of their performance and relevance of the content delivered as it pertained to their audience. Data was aggregated and provided in summary to the TLs to keep the district teachers anonymous. The Project Coordinator and Network Coach worked with the TLs to continually improve their PD in light of the feedback gathered from this instrument.

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". After each session, modes and medians were determined and written comments provided by the district teachers were included in the evaluation report. Original forms were not shared with the teachers or the leadership team to keep the identity of the district teachers private and to encourage them to speak freely. A summary of the feedback is presented in Table 6 by group.

Table 6: PD Feedback Summary

Group	Mode	Median	Unusual items
High schools	3	3	None
TPS Middle	4	4	Item 4 had mode/median of 3: *I learned new teaching strategies today.* Item 6 was bimodal (3 and 4): *I will integrate the teaching strategies I learned into my classroom.*
TCS Middle	4	4	None
TCS Elem.	4	4	None

Evaluation team observations of the PD sessions verified that the high school audience was more demanding than the lower grades. TLs providing PD to high school teachers should strive to provide challenging content as many of the high school district teachers have strong content background.

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. First teachers were asked about their preferred scheduling format. Most agreed across groups that something somewhat spread out (like every other week) would allow them to try things out before the next session. Having sessions somewhat close together (rather than once a month) enables them to then report back and discuss their results. They also felt that more information like a syllabus for the entire series of sessions should have been provided prior to the onset of the first PD. They recommended that future sessions take place in the fall, during the school day, so that they have time to integrate the information into their classrooms during the spring (in fact, the original LEADERS design). Overall, they liked the daily schedules and found them engaging.

All of the district teachers felt they learned from the sessions and specifically noted that they learned about solar energy, new vocabulary/terminology, and how to use new equipment. They realized through implementation of aspects of PBS that their students lack essential problem solving skills they will need for employment in science-related careers. The teachers enjoyed implementing PBS, are now more likely to take risks in the classroom, and noticed that student disciplinary problems disappeared during PBS activities. The TLs provided resources and the teachers appreciated the supplies they were given to use in their classrooms. They expressed hope that their interaction with their groups as well as with the TLs will continue and are interested in learning more. They would like help in the classroom whether it be the TLs, LEADERS graduate students, or University of Toledo scientists. After a somewhat bumpy beginning (provision of information about the sessions was sketchy resulting in reluctant attendees at the onset), the PDs were successful and well received.

H. Science Cafe

To support the TLs, LEADERS proposed using a virtual space for interaction in the following manner:

> "To facilitate communication and networking among teacher leaders (between and within school districts), project staff, and supporting partners, an innovative element of LEADERS is the use of a *Science Café*, developed as part of this project, to engage our community of teacher leaders throughout the AY. The *Science Café* will be a virtual meeting space that utilizes an online environment supporting productive and professional collaborations. (LEADERS Proposal pg. 11)"

Sharepoint™ was used as the main platform for accomplishing these goals. A University-based site (ALCOT), where recordings of all summer institute sessions were available for review but not comment, supplemented this site. For the 2010 summer institute there were five main pages used. One of these pages was a homepage from which the other four sites, one for each of the courses included in the institute, could be accessed.

An analysis of posts made before 6/1/2011 to the four course sites demonstrated the following:

- There were about 400 posts made across the four course pages (mean= 96; min = 48 posts to leadership course; max = 126 posts to chemical energy course)
- Approximately 45% of these posts were required assignments, 45% were information uploaded by members of the project team or course instructors, 8% were resources uploaded by the education specialists working with the scientists on their courses and 2% were information or resources uploaded by TLs.
- Scientists did not appear to utilize the site; the only post by a scientist other than one of the PIs was a course syllabus.
- No instance of discussions was observed. A total of three posts were made to discussions boards. All these posts were by members of the project team and elicited no response.
- No instance of feedback provided TLs was observed although TLs did not initiate requests for feedback.
- Access of supporting partners was limited to the two administrators who had attended parts of the 2010 Summer Institute.
- No business partners had access to the site.

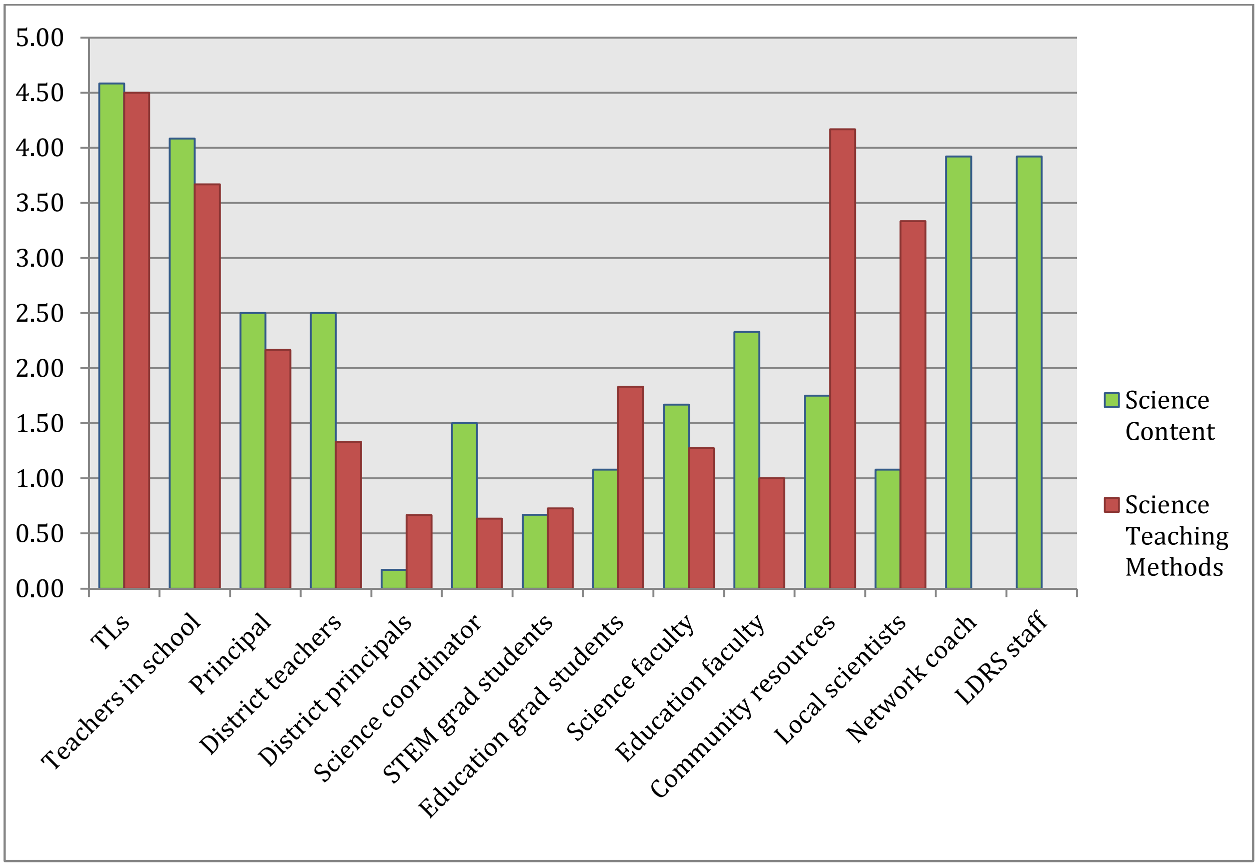
In addition to these four sites an additional site for PD planning was set up during the academic year. The majority of posts to this site were either resources posted by the project team staff or required PD plans posted by TLs.

The majority of posts to Science Café have been information posted by the project team or required assignments posted by teacher leaders. Instances of discussion or feedback were not observed and content and pedagogy experts did not utilize the site to network with TLs or the project team. The site is not currently providing support for the kinds of "productive and professional collaborations" described in the proposal. It is recommended that the leadership team explore reasons why TLs and other members of the partnership like scientists are not making use of the site and what improvements might be made to make it a viable resource to improve networking and communication.

I. Professional Networking

To determine the extent to which TLs will broaden their professional support network, and to determine the extent to which partners in LEADERS interact with the TLs, a professional network survey was administered spring 2011 and will be re-administered annually. The following frequency charts illustrate with and from whom TLs are currently networking and gathering support. Data presented is the average frequency reported by the 12 TLs.

Chart 1: *How frequently did you confer with the following concerning* ***science content*** *and* ***science teaching methods*** *during the school year 2010-2011?*



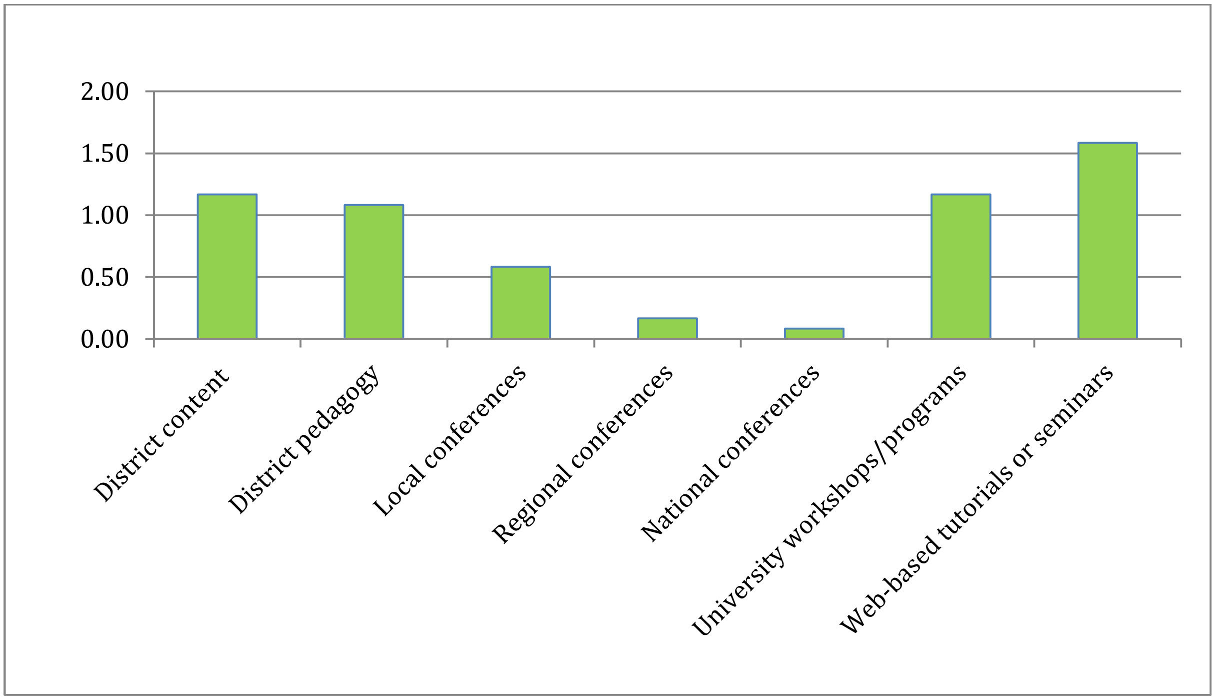
0 = never 1 = yearly 2 = quarterly 3 = monthly 4 = bi-monthly 5 = weekly

(*Network coach and LDRS staff not included in science teaching methods question—accidentally omitted)

Other TLs, other teachers in their schools, and the LEADERS Network Coach and other staff provided the majority of support for the TLs during the past year. Community resources such as science museums and local scientists provide some science teaching support, most likely in the way of providing field trip destinations or through curriculum ideas posted on their websites. It is interesting how little interaction the teachers reported having with their district science coordinators (less than quarterly). Graduate students have limited interaction with the TLs but could prove to be a valuable resource in both content and pedagogy not only for the TLs but also for the district teachers as they implement renewable energy science lessons.

Other than participation in LEADERS, the TLs have limited access to science and science education professional development events (Chart 2). Most attend one district content and one district pedagogy professional development workshop per year and seldom attended professional science education conferences. The professional development provided by LEADERS has provided the TLs with an opportunity to engage in professional growth not otherwise possible.

Chart 2: *During the current school year, how often have you attended the following science and/or science education professional development activities* ***outside of LEADERS****?*



0 = never 1 = once 2 = twice 3 = 3 times

TLs were also asked to quantify the usefulness of the professional development they received over the past year. Specifically, they were asked what percent of the professional development in which they engaged was applied to various relevant situations. The results are in Table 7.

Table 7: Usefulness of professional development over the past year

	LEADERS	Other PD
What percent of the past year's total professional development activity was directly linked to your classroom instruction?	67	40
What percent of the past year's total professional development activity helped you learn new scientific inquiry techniques?	70	38
What percent of the past year's total professional development activity helped you implement new instructional strategies?	64	35
What percent of the past year's total professional development activity helped you learn new science content?	70	33
What percent of the past year's total professional development helped you learn to use new science and technology tools for the classroom?	59	37
Overall, what percent of what you have learned through the NSF LEADERS project is integrated in your classroom?	70	N/A

It is clear that the professional development provided to the TLs over the past year has been useful and relevant.

III District Science Teachers

Teachers were assigned to treatment and control groups based upon a random assignment of schools—cluster assignment. All science teachers within the treatment and control schools were asked to complete three surveys—renewable energy content, STIPS, and STEBI-A. Response rates are provided in Table 8. A total of 131 teachers completed all the surveys: 59 from the treatment schools and 72 from the control schools. These numbers reflect a disconnection between the district administration and the teachers. Partner districts assured the evaluation team near 100% cooperation. Grade level distributions by districts were as follows:

Table 8: Response rates of district teachers

	Toledo Public Schools			Toledo Catholic Schools		
Grade	Population	Responded	Resp. Rate	Population	Responded	Resp. Rate
Elementary	116	15	13%	114	54	47%
Middle	43	12	28%	38	12	32%
High School	53	19	36%	42	19	45%
Total	212	46	22%	185	85	46%

To improve response rates for next year, the leadership team has asked the Toledo Federation of Teachers union to provide a representative to join the LEADERS partnership. In addition, the evaluation team will provide districts, TLs, and principals with a calendar of data collection so that teachers can be made aware of collection times well in advance.

A. Content Tests

The evaluation post doc (Brooks) collaborated with science and education graduate students to develop the content assessment for district teachers. The first step was a review of project goals and curriculum standards to determine areas of content knowledge that were important to address in the evaluation of project impact. Five main areas of content understanding were identified:

a. Relevant curriculum standards
b. Science process skills
c. Renewable energies
d. Renewable energies in the Great Lakes Region
e. Project Based Science

Questions that fit these areas were compiled from various education and content oriented websites. For more general areas (a-c) validated questions were gathered from sites that included the National Assessment of Educational Progress (NAEP; http://nces.ed.gov/nationsreportcard), Program for International Student Assessment (PISA; http://nces.ed.gov/surveys/pisa), the Ohio Department of Education (ODE; http://www.ode.state.oh.us), and National Energy Education

Development (NEED; http://www.need.org). Questions were crafted for areas specific to project goals (d-f) and reviewed by science and education experts for validity.

The TLs were asked for their feedback after all questions had been reviewed by experts. They were asked to indicate which questions were most relevant to the content addressed in the professional development sessions they were designing and which were appropriate for teachers at the grade levels their PD would target. Based on TL feedback, a preliminary content test was developed. Once developed, PIs and appropriate project staff were asked to provide feedback and the test refined until all reviewers were satisfied. There were 37 items on the test.

Treatment and control teachers were compared using an independent sample t-test to verify group equivalency. Because the sample sizes were unequal, Levene's Test was first performed to verify equality of variances (variances were equivalent; p = 0.47). Scores on the test ranged from 0 (4 people) to 36 (3 people). The t-test for independent samples showed the groups to be equal on the content test therefore verifying our assumption of equivalent groups:

Table 9: Comparison of Treatment and Control District Teachers

Group Statistics

	1= trmt, 2=control	N	Mean	Std. Deviation	Std. Error Mean
TOTAL	1	59	21.69	9.27	1.22
	2	72	23.73	8.64	1.03
	t = 0.341; **p = 0.735**				

Performance on the test was as expected (below 75%) because the items tested renewable energy science—content to which the teachers have not yet been exposed. Item analysis using Rasch modeling showed the test to have an item reliability index of 0.92. Based upon calculations of item difficulty, P ($\frac{correct}{37}\, items$), one item was considered hard (P < 0.25) and 8 were considered easy (P > 0.75). The remaining 28 items fell in the average range. An examination of item discrimination, where D =

$$(\#correct\ in\ top\ 30\% - \#correct\ in\ bottom\ 30\%)/(\text{top} + \text{bottom}),$$

showed that none of the items had discrimination strength or direction. In other words, the difference between those who answered an item correctly and scored high on the test and those who answered the same item correctly and scored low on the test was insignificant suggesting that general knowledge of the topic did not affect the likelihood of answering an individual item correctly. This could be due to a couple of factors. First, the renewable energy content on the test was new to many teachers thereby increasing the likelihood that respondents guessed. Second, it was reported to the evaluation team during a TL focus group interview that district teachers were accessing the internet while taking the online test to find correct answers to the items. Revisions to the test will be made over the summer to develop items that have stronger discrimination power and future administrations of the test will be timed to discourage “hunting” for correct answers on the web.

B. Teaching Preferences and Self Efficacy

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. For the STEBI and STIPS subscales, scores were converted to reflect an expected mean of 25. A comparison of means and the t statistic are provided below:

Table 10: Overall district teacher baseline data for attitudinal measures

Toledo Public Schools (Treatment n = 15; Control n = 31)				
Instrument	Treatment mean	Control mean	t statistic	p
STIPS Inquiry	29.05	31.34	0.84	0.41
STIPS Non-inquiry	20.23	21.57	1.04	0.30
STEBI Personal Beliefs	28.77	26.88	6.58	0.75
STEBI Outcome Exp.	23.26	23.44	1.37	0.89
Toledo Catholic Schools (Treatment n = 44; Control n = 41)				
Instrument	Treatment mean	Control mean	t statistic	p
STIPS Inquiry	28.03	27.99	0.26	0.98
STIPS Non-inquiry	21.30	22.30	1.14	0.26
STEBI Personal Beliefs	28.23	26.54	1.19	0.27
STEBI Outcome Exp.	23.49	23.70	0.20	0.84

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. On the STEBI, teachers scored slightly higher in their belief that they can provide quality instruction but slightly below the expected men in their expectation that good teaching practices will improve student learning. A multivariate comparison was conducted to compare the two districts on the four measures. Groups were equivalent on all measures except the STIPS Inquiry scale. TPS teachers showed a statistically significantly higher preference for inquiry instruction than TCS ($t = 2.04$, $df = 129$, $p = 0.04$). Data from this year will be compared with data collected on the same measures next year to examine change over time.

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. The student knowledge of renewable energy content and area commercial activity was not assessed this year; baseline is scheduled to be collected fall 2011.

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 2010 science tests were compared between treatment and control schools per grade level to establish group equivalency and to set a baseline. 2011 scores will not be available until summer and will be reported in the next reporting period. Table 11 shows the comparison of student performance:

Table 11: TPS Ohio Achievement Test in Science Passing Rates

Treatment Schools	Total Students	Number Passing	% Passing
Total 5th grade	2870	1519	0.53
Total 8th grade	1574	618	0.39
Total HS	3171	2271	0.72
Control Schools			
Total 5th grade	3243	1889	0.58
Total 8th grade	1915	885	0.46
Total HS	3267	2810	0.86

A Chi Square test of Independence was performed to verify group equivalency. Results indicated equivalent performance on the 2010 tests at each grade level ($p = 0.98$).

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*. Modifications were made for middle and elementary school students. Dr. Eileen Carr, an expert in elementary and middle school reading and University of Toledo Curriculum and Instruction professor, verified that the revised surveys were written in language that was grade-level appropriate. Dr. Amy Allen, University of Toledo Early Childhood Education faculty member, examined the survey for elementary school and made formatting suggestions to strengthen internal validity by reducing the amount of incorrect answers due to student clerical errors. These surveys were administered to students in grades 3 through 9 at the combined 28 treatment and control schools between May 23 and June 3, 2011. They are in the process of being recorded and analyzed and baseline information will be included in the next reporting cycle.

Originally set to be collected in February-March, administration of these surveys was delayed due to scheduling difficulties with the school districts noted in Section I. The evaluation team faced several hurdles in the collection of student data. One reason we waited until the end of the school year to administer the survey was because TPS administration scheduled meetings with principals and thought that introducing the surveys and explaining the process would be best facilitated at that time. Unfortunately, meetings with middle and secondary school principals were cancelled and so we had no opportunity to speak with these principals prior to survey administration. We did have this opportunity to meet with elementary school principals and those schools were cooperative and pleasant. Some TPS middle and high schools, however, were confused when the surveys were delivered. One high school refused to administer the survey. It is recommended that the evaluation team and TPS administration meet with school principals and building representatives early in the school year fall 2011 to ensure all schools are aware of the necessity to gather data about this project. Analysis of the baseline data will be provided in the next annual report and compared with next year's administration of the survey.

V The Partnership

During the past year exploratory data has been collected from higher education partners (scientists and engineers) and business partners. This information has been used to better understand of how the partners view their roles in LEADERS, determine whether partners hold any misconceptions about K-12 science education, develop a standardized set of questions to ask annually to examine change in partner relationships, and to prompt the partners to think about how each might contribute to the success of the project. Beginning fall 2011, partners will provide responses to the LEADERS Levels of Collaboration Survey based upon the work of Frey, Lohmeier, Lee, and Tollefson (2011). The adaptation of the model to the LEADERS project was based upon information gathered from the exploratory data.

A. Higher Education Partners (Science and Engineering Faculty)

Two scientists/engineers (not including PI) were involved in the 2010 Summer Institute and four are involved in the 2011 Institute. Information collected from the MSP MIS survey last year indicated that the faculty partners participating last year both learned practical information about pedagogy that they have applied to courses at the University. Specifically, one mentioned the use of "jigsaw pedagogy" and the other learned to use assessment for many purposes beyond just calculating student grades (e.g., to assess pre-existing knowledge levels).

Three of five faculty members serving on the Partnership Board responded to the exploratory survey. The faculty members supported the idea of incorporating more project based instruction into the K-12 classroom and supplemented with real world applications including the business side of science and engineering. Current interactions with other partners included working with faculty from other departments on campus (a few times a year to weekly), working with science-related businesses (a few times a year to monthly), and limited interaction with K-12 teachers (once or twice a year). All felt university faculty could better interact with K-12 students to improve education. Examples included assisting with competitions and science projects and visiting classrooms to instill "passion among the students so that they become interested in the subject matter."

B. Business Partners

Five of the 13 business partners serving on the Partnership Board responded to the survey. They represented a home construction company, a solar photovoltaic design and build company, a “renewable energy” company, a company that produces and markets grain, fertilizer, and industrial products, and a private company that focuses on science and technology. In general, the business partners had realistic views of what occurs in a typical grades 3-12 science classroom. None held stereotypes about the way science is taught and a few were quite knowledgeable as a result of involvement in the classrooms themselves. They felt that science education could improve if more emphasis was placed on critical and dynamic thinking, if students better understood the integral part science plays in society and business, and an emphasis on the relevance of science to everyday life through interaction with scientists and science-related businesses. Only one of the business representatives meet with university STEM faculty more frequently than once or twice a year and three do not interact with faculty at all. Four of them interact with K-12 schools at least a few times a year and three interact with other science-related businesses and industries at least quarterly. Because the majority of the members have not yet responded to the exploratory survey, conclusions cannot be drawn. However, this information does provide some insight as to the “beginning point” of the partnership.

VI Summary

In many areas the project is moving towards goal attainment. Most importantly, the TLs, from their own perspective and from that of the district teachers, have successfully assumed leadership roles within their districts. While in general the project is moving smoothly and as designed, the project leadership and implementation team should focus efforts on: (1) Reinforcing PBS principles and implementation with the TLs; (2) Improving cooperation with districts in both promoting and supporting the LEADERS professional development sessions and in facilitating data collection for evaluation and research; (3) Expanding the roles of higher education and business partners so that they become actively involved on a regular basis.

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APPENDIX

Science Teacher Inquiry Preferences Survey (Jones & Harty, 1978)
(Note: *indicates inquiry scale; all others, non-inquiry scale)

The purpose of this survey is to get an idea of your perspective about teaching science. There are no correct or incorrect answers. Please check the box of your level of agreement with each of the following statements where 0 = no agreement and 5 = 100% agreement

1. Science should be taught as a discipline of conclusive and authoritative information that has been verified beyond dispute.
   0 1 2 3 4
2. *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.
   0 1 2 3 4
3. During instruction, the student should be explicitly told the important concepts contained within the content dealing with the topic being studied.
   0 1 2 3 4
4. *To learn science, the student should be provided situations that exemplify concepts but which require him or her to figure them out himself or herself from the examples encountered.
   0 1 2 3 4
5. Students best learn important concepts of science through direct presentation of them by the teacher.
   0 1 2 3 4
6. *In the lab, the student should be free to identify on his or her own the relevant questions and means of investigation for pursuing possible results.
   0 1 2 3 4
7. To truly understand the science discipline, students should acquire a fund of useful factual information dealing with the content under consideration.
   0 1 2 3 4
8. *Students should have a major role in making decisions about what are the best means for learning the concepts in the material being studied.
   0 1 2 3 4
9. During lab exercises, students should follow specific directions on what to observe, measure, and report to find the right answers to the problem.
   0 1 2 3 4
10. *The learning of scientific concepts should include the alternative views, weaknesses of current explanations, and doubts about the validity of the conclusions.
    0 1 2 3 4
11. The true nature of science should be illustrated to the student through the study of its technological applications and achievements.
    0 1 2 3 4
12. *Instructional materials must encourage students to formulate alternative ideas to concepts encountered.
    0 1 2 3 4

13. Lab experiments should be designed so that the correct results or answers will emerge for only those who follow the directions and procedures.

    0 1 2 3 4

14. Investigations should follow the “scientific method” as the best means for all to use to make discoveries.

    0 1 2 3 4

15. *To learn a scientific law or principle, students should be provided exemplifying instances from which they infer it without the teacher giving it.

    0 1 2 3 4

16. *Students should encounter new concepts to be learned in lab investigations before they are covered in class.

    0 1 2 3 4

17. The primary objectives of lab experiments should be the development of manipulative skills and ability to follow directions, which lead to planned results.

    0 1 2 3 4

18. Lab investigations should follow specified directions and procedures designed to illustrate a concept.

    0 1 2 3 4

19. *Students must challenge the truth of currently held scientific concepts and principles by seeking alternative interpretations that they can formulate, justify, and substantiate.

    0 1 2 3 4

20. *Each student should use his or her own ways of exploring, interpreting, and reporting the experiences done by everyone during a lab investigation.

    0 1 2 3 4

Project-based Science (PBS) Survey

Name: ______________________________

Please indicate how much you agree with the following statements. Please check only one response for each question.

a. *In theory*, PBS represents best practices in science instruction; all instruction should be done in this format

☐ Strongly agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

b. *In practice*, PBS represents best practices in science instruction; all instruction should be done in this format.

☐ Strongly agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

c. PBS represents one of a spectrum of valuable approaches to instruction. Good science instruction should include both project-based and non-project-based instruction.

☐ Strongly agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

d. PBS should serve as an overlay to traditional instruction, providing a connecting framework. It enhances traditional instruction but is not critical in science classrooms.

☐ Strongly agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

e. PBS is useful as a motivator to get students to learn material. PBS should serve as a reward in science classrooms but it not a way to convey content to students.

☐ Strongly agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

f. PBS is a distraction in secondary science classrooms. This format of instruction does not contribute to learning.

☐ Strongly agree ☐ Agree ☐ Disagree ☐ Strongly Disagree

Please continue to the next page!

1. What do you consider to be the key elements of Project-based Science? In other words, how would you recognize PBS in a math or science classroom?

2. Briefly describe how you plan to implement PBS over the next school year (if at all).

3. Which of the following best characterizes your feelings about how the PBS course has prepared you to implement PBS

   ☐ I feel completely prepared for a full implementation of PBS.

   ☐ I feel fairly well prepared to implement PBS at some level.

   ☐ I don't feel that I am any better prepared to implement PBS than I was before I took this course.

   ☐ I feel less confident and enthusiastic about PBS after my experience in this course than I did before.

   Please explain your answer and list what experiences in this course were particularly helpful in preparing you or discouraging you from implementing PBS.

4. What do you see as possible barriers to implementing your plans for PBS?

LEADERS Professional Development Feedback Survey

	Not at all			To a great extent
1. I understood the purpose of the session.	1	2	3	4
2. I was intellectually engaged with important ideas relevant to the focus of the session.	1	2	3	4
3. I learned new content today.	1	2	3	4
4. I learned new teaching strategies today.	1	2	3	4
5. I will integrate the content I learned into my classroom.	1	2	3	4
6. I will integrate the teaching strategies I learned into my classroom.	1	2	3	4
7. The depth and breadth of science content was appropriate for my needs.	1	2	3	4
8. Appropriate connections were made to other areas of science and math, other disciplines, and real world contexts.	1	2	3	4
9. The design of the session reflected careful planning and organization	1	2	3	4
10. The design of the session encouraged a collaborative approach to learning	1	2	3	4
11. Adequate time and structure were provided for participants to share experiences and insights.	1	2	3	4
12. Adequate time and structure were provided for "sense-making," including reflection about concepts, strategies, issues, etc.	1	2	3	4
13. The facilitator(s)' understood their subject matter.	1	2	3	4
	Not at			To a

	all			great extent
14. The pace of the session was appropriate.	1	2	3	4
15. The session modeled effective assessment strategies.	1	2	3	4
16. Facilitator(s) displayed an understanding of pedagogical concepts (e.g., in their dialogue with participants).	1	2	3	4
17. Depth and breadth of attention to classroom strategies intended for classroom use were appropriate for the purposes of the session and participants' needs.	1	2	3	4
18. Active participation of all participants was encouraged and valued.	1	2	3	4
19. There was a climate of respect for participants' experiences, ideas, and contributions.	1	2	3	4
20. I was encouraged to generate ideas, questions, conjectures, and propositions during this session.	1	2	3	4
21. I would recommend this session to other teachers.	1	2	3	4

Use this space to elaborate on any of the items above or to add other comments:

Content Assessment for District Teachers

The Toledo area has been included as part of the Green Belt. Why?

1. Toledo is using modern technology to create highly productive agriculture.
2. Toledo is transforming its industrial manufacturing infrastructure to create renewable energy technology.
3. Toledo has imposed growth boundaries.
4. Toledo is a leader in urban agriculture, converting abandoned inner city properties to productive farms.
5. I don’t know.

What two gases make up most of the Earths atmosphere?

1. Hydrogen and oxygen
2. Hydrogen and nitrogen
3. Oxygen and carbon dioxide
4. Oxygen and nitrogen
5. I don’t know

Which of the following statements about Project-Based Science is FALSE?

1. PBS should never include teacher-driven lecture.
2. PBS encourages students to develop critical thinking skills.
3. The driving question of a PBS unit must be chosen to reflect real interests and concerns in the lives of students and in the communities in which they live.
4. PBS helps students learn how to monitor their own learning.
5. I don’t know.

Which of the following lists contains only renewable energy sources?

1. Oil, Wood, Wind
2. Geothermal, Solar, Coal
3. Solar, Wind, Geothermal
4. Coal, Oil, Natural Gas
5. I don’t know

A scientific study showed that the depth at which algae were found in a lake varied from day to day. On clear days, the algae were found as much as 6 meters below the surface of the water but were only 1 meter below the surface on cloudy days. Which hypothesis best explains these observations?

1. Nitrogen concentration affects the growth of algae.
2. Precipitation affects the growth of algae.
3. Light intensity affects the growth of algae.
4. Wind currents affect the growth of algae.
5. I don’t know.

The diagram below shows a pendulum in motion. Which describes the potential and kinetic energy of the pendulum at position X?

1. Potential energy is at its lowest and kinetic energy is at its lowest.
2. Potential energy is at its highest and kinetic energy is at its lowest.
3. Kinetic energy is at its highest and potential energy is at its lowest.
4. Kinetic energy is at its highest and potential energy is at its highest.
5. I don’t know.

Wood, waste, landfill gasses and alcohol fuels are all examples of what?

1. Biomass Energy Sources
2. Geothermal Energy Sources
3. Hydropower
4. Fossil Fuels
5. I don’t know

Which example of student interactions would be the best indicator that project-based science is going on in a classroom?

1. Students work in small groups to complete a worksheet based on information from their textbooks.
2. In order to gain the background knowledge necessary to begin an experiment students read a book chapter quietly at their desks.
3. While working in groups, students critique each others claims, evidence and reasoning that stem from the results of a recent experiment.
4. Students use the Internet to gather information about a topic they will present to the class as the final project for a unit.
5. I don't know

Which of the following is an example of using a renewable energy source?

1. Traveling by train from Toledo to Boston
2. Using a gasoline powered lawn mower to cut your grass
3. Burning coal to generate steam that turns turbines which generate electricity
4. Damming water to direct its flow through a turbine to produce electricity
5. I don't know

Which of the following is the most true about a good scientific hypothesis?

1. It ensures that successful results will be obtained from an experiment.
2. It must be accepted as true by the scientific community.
3. It is a testable proposal that may lead to experimentation.
4. It must be formulated by a renowned scientist.
5. I don't know.

Which of the following is NOT one of Newtons three laws of motion?

1. Energy cannot be created nor destroyed.
2. For every action there is an equal and opposite reaction.
3. Without any external forces being exerted on it, an object in motion tends to stay in motion.
4. Force equals mass times acceleration.
5. I don't know.

Pat has two kinds of plant food, Quickgrow and Supergrow. What would be the best way for Pat to find out which plant food helps a particular type of houseplant grow the most?

1. Put some Quickgrow on a plant in the living room, put some Supergrow on a plant of the same type in the bedroom and see which one grows the most.
2. Find out how much each kind of plant food costs because the more expensive kind is probably better for growing plants.
3. Put some Quickgrow on a few plants, put the same amount of Supergrow on a few other plants of the same type, put all the plants in the same place and see which group of plants grows the most.
4. Look at the advertisements for Quickgrow, look at the advertisements for Supergrow and see which one says it helps plants grow the most.
5. I don't know

Global warming focuses on an increase in the level of which gas in the atmosphere?

1. Ozone
2. Sulfur dioxide
3. Carbon dioxide
4. Nitrous oxide
5. I don't know

Toledos presence in what historical manufacturing industry led to its new found role in the renewable energies industry?

1. Automobiles
2. Glass

3. Uranium
4. Textiles
5. I don't know

US Energy Consumption by SourceBased on the information in the above graph, how much of the US energy comes from fossil fuels?

1. 61%
2. 92%
3. 84%
4. 60%
5. I don't know

Coal has formed from?

1. Dead and decayed vegetation that lived over hundreds of millions of years ago in swampy forests.
2. Compacted dinosaur remains
3. Dead and decayed vegetation that lived hundreds of years ago in swampy forests
4. Anaerobic bacteria interacting with minerals embedded in the Earths mantle.
5. I don't know

Which four factors determine the amount of solar radiation that reaches a specific place on Earth?

1. Geographic location, time of day, season and local weather
2. Geographic location, day of the week, season and phase of the moon
3. Season, time of sunrise, time of sunset and concentration of atmospheric gases
4. Local weather conditions, time of sunset, available atmospheric water vapor and concentration of carbon dioxide.
5. I don't know

Energy is released during ________ reactions.

1. Endothermic
2. Polythermic
3. Exothermic
4. Monothermic
5. I don't know

Which sentence best states the importance of using control groups?

1. Control groups reduce the number of measurements needed by eliminating the need for large sample sizes..
2. Control groups simplify calculations by eliminating the need for statistical tests.
3. Control groups provide a method by which statistical variability can be reduced.
4. Control groups narrow the possible causes of outcomes by comparing subjects receiving a treatment with those that do not.
5. I don't know.

Which of the following scenarios is the best example of Project-based science?

1. Students view pictures of thermal fish kills and discuss their ideas about why the fish died in these situations. Students are then given probes that can measure dissolved oxygen, thermometers, heaters, salt and water and asked to write down an experimental design and their hypotheses about what will happen to oxygen as temperature increases. Students then conduct the experiment and record their results. Graphs showing the groups' results are created and students discuss their findings and conclusions.
2. Students watch a video about the relationship between the ozone and skin cancer. They are then given a series of questions to answer about ozone and computers so they can search the Internet and find the answers. Questions include: Which layer of the atmosphere is it normally found? What do scientists believe decomposes in the atmosphere to destroy ozone? Students create and present PowerPoint presentations to the class about their answers to these questions.
3. The teacher poses the question to the class: How clean is the water in the stream behind our playground? Students take a walk to observe the stream and when they return to the classroom discuss their ideas about how they could investigate water quality. Several good suggestions are made and students deign methods by which

they will collect information. Students work in groups to collect their data and make a presentation to the class about what they found. These initial findings lead to more in depth

4. A scientist from a local university gives a presentation about her research to a chemistry class. Students are then asked to choose a field they are interested in and research job opportunities in that field. They use the internet to write a paper about their chosen field and give a presentation to the class about what they learned.
5. I don’t know

Which of the following challenge the feasibility of using large scale renewable energy production to replace fossil fuels for electrical power generation?

1. Large-scale renewable energy production like solar and wind farms are often located in remote areas and are not easily connected to the electric grid.
2. The availability of renewable technology prohibits building facilities large enough to make an impact
3. Variations in wind and solar energy prohibit building sites for large scale production.
4. The current electrical grid is unable to carry the type of electricity which is produced at solar and wind facilities.
5. I don’t know.

Which renewable energy industry has a significant manufacturing presence in the Toledo area?

1. Wind
2. Solar
3. Biomass
4. Oil
5. I don’t know

First Solar is a good example of:

1. A business that has moved to the Toledo area to take advantage of existing infrastructure.
2. A company that produces quality project based science kits for use in classrooms.
3. An existing local company that has been re-engineered to take advantage of existing infrastructure.
4. A business that has emerged from research findings at Toledo-local universities.
5. I don’t know.

Which of the following lists contains all elements that are essential to project based science?

1. Student-driven research, teacher-driven lectures, and data manipulation.
2. On-going assessments, worksheets, and inquiry.
3. Student-driven research, data manipulation, and on-going assessment.
4. New vocabulary, teacher-driven lectures, and worksheets.
5. I don’t know.

When propane gas reacts with oxygen in the air to form carbon dioxide and water, heat is released. What is the source of this heat energy?

1. The kinetic energy of the oxygen.
2. The kinetic energy of the propane.
3. The nuclear energy stored in the oxygen and propane.
4. The chemical energy stored in the oxygen and propane.
5. I don’t know

What process is occurring at point A in the above illustration?

1. Evaporation
2. Condensation
3. Precipitation
4. Runoff
5. I don’t know

Through the process of photosynthesis, plants are converting energy of one form into another. Which of the following energy transformations are occurring?

1. Nuclear energy from the sun is converted into chemical energy in the form of glucose.

2. Radiant energy from the sun is converted into chemical energy in the form of glucose.
3. Thermal energy from the sun is converted into chemical energy in the form of glucose.
4. Chemical energy from the sun is converted into electrical energy in the form of electricity.
5. I don’t know.

Which of the following statements best describes why we have seasons?

1. The Earth is closer to the sun during summer than it is in the winter.
2. The Earth’s axis is tilted in comparison to its orbital axis.
3. The Sun burns hotter in the summer than it does in the winter.
4. More of the sun’s heat is trapped in the earth’s atmosphere during the summer because of changes in the thickness of the ozone layer.
5. I don’t know.

Which of the following is true about the biofuel Ethanol?

1. Ethanol can only be used in fuel cells.
2. Ethanol has much higher energy content than gasoline but is less efficient.
3. Ethanol has a low energy return on energy invested.
4. Ethanol is naturally occurring and only need filtered to be a usable biofuel.
5. I don’t know.

A solar cell converts:

1. Heat energy into electrical energy
2. Solar energy into electrical energy
3. Heat energy into light energy
4. Solar energy into light energy
5. I don’t know

Air in the atmosphere continuously moves by convection. At the equator, air rises; at the poles, it sinks. This occurs because:

1. The Earth’s ozone layer is thinner at the equator than at the poles.
2. The Earth’s magnetic field is stronger at the poles than at the equator.
3. Warm air can hold less water vapor than can cold air.
4. Warm air is less dense than cold air.
5. I don’t know.

Based on the information in the table above, which is a reasonable hypothesis regarding elements and their compounds?

1. An element retains its physical and chemical properties when it is combined into a compound.
2. When an element reacts to form a compound, its chemical properties are changed but its physical properties are not.
3. When an element reacts to form a compound, its physical properties are changed but its chemical properties are not.
4. Both the chemical and physical properties of a compound are different from the properties of the elements of which it is composed.
5. I don’t know.

Household appliances convert electricity into one or more different forms of energy. An electric fan can best be described as converting electricity into

1. Heat energy only.
2. Heat energy and sound energy only.
3. Heat energy, sound energy, and mechanical energy only.
4. Heat energy, sound energy, mechanical energy, and chemical energy.
5. I don’t know.

Which of the following would make the best driving question for a Project-Based Science (PBS) unit?

1. What is the chemical composition of oil?
2. How do nuclear, oil and solar energies compare?
3. How clean is the water in the stream behind our playground?
4. How are batteries recycled?
5. I don't know

Which of the following is true for chemical compounds that have been detected elsewhere in the universe?

1. They have a greater average density than the same compounds found on Earth.
2. They are composed of the same elements that are found on Earth.
3. They are less reactive chemically than the same compounds found on Earth.
4. Those with the greatest molar masses are found furthest away from our solar system.
5. I don't know.

Which of the following statements about the role of assessment in project based science is FALSE?

1. PBS assessment needs to measure meaningful understanding.
2. The result of PBS needs to include a tangible product.
3. Students should be engaged in the PBS assessment process.
4. PBS assessment should only include measures that can be given a numerical score.
5. I don't know.

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Which of the following is the truest about a good scientific hypothesis?

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Toledos presence in what historical manufacturing industry led to its new found role in the renewable energies industry?

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3. Uranium
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US Energy Consumption by SourceBased on the information in the above graph, how much of the US energy comes from fossil fuels?

1. 61%
2. 92%
3. 84%
4. 60%
5. I don't know

Please use the graph below to answer the next TWO questions.Based on this graph, Wind energy has the highest average energy return on energy invested (EROI). Which renewable resource has the greatest variation in its potential energy return on energy invested?

1. Coal
2. Geothermal
3. PV (photo voltaic)
4. Wind
5. I don't know

Based on this graph, Wind energy has the highest average energy return on energy invested (EROI). Which renewable resource has the lowest average energy return on energy invested?

1. Solar Thermal
2. Geothermal
3. PV (photo voltaic)
4. Wind
5. I don't know

University of Toledo LEADERS Project Student Survey Grades 3 and 4

Please answer the following about science. There are no “correct” answers.

Mark the box to show your answer

Most people can understand science if they try.	Yes	Maybe	No
Science is important to my family.	Yes	Maybe	No
I like to study science.	Yes	Maybe	No
I use science every day.	Yes	Maybe	No
It is important for everyone to know science.	Yes	Maybe	No
Having a job in science would be fun.	Yes	Maybe	No
Everyone should study science at school.	Yes	Maybe	No
I have read books about science on my own.	Yes	Maybe	No
I like to learn about new scientific discoveries.	Yes	Maybe	No
Science creates jobs for people.	Yes	Maybe	No

University of Toledo LEADERS Project Student Survey Grades 5 and 6

Please answer the following questions truthfully selecting the response that best fits your opinion. There are no “correct” answers.

Use the following scale for your answers:

a = Agree   b = Agree more than disagree   c = Disagree more than agree d = Disagree

ATTITUDE TOWARDS SCIENCE/LEARNING SCIENCE

This set of statements addresses your attitudes towards science and your attitudes towards learning science.

1. Most people can understand science if they try.
2. Science is important to our society.
3. I feel confident studying science.
4. I use science in my everyday life.
5. People should understand science because it affects their lives.
6. Scientific work is useful to everyone.
7. I may not make great discoveries, but working in science would be fun.
8. Everyone should have to study science at school.
9. I like to read books about science.
10. I like to learn about new scientific discoveries.
11. I would like to have a job that involves science.
12. Science creates jobs in the Toledo area.
13. Science affects the lives of people in the Toledo area.
14. It is important to protect our environment.
15. Using renewable energy sources is an important part of protecting our environment.
16. Renewable energies create jobs in the Toledo area.

University of Toledo LEADERS Project Student Survey Grades 7, 8 and 9

Please answer the following questions truthfully selecting the response that best fits your opinion. There are no "correct" answers.

Use the following scale for your answers:

a = Agree b = Agree more than disagree c = Disagree more than agree d = Disagree

ATTITUDE TOWARDS SCIENCE/LEARNING SCIENCE

This set of statements addresses your attitudes towards science and your attitudes towards learning science.

1. Most people can understand science if they try.
2. Science is relevant to our society.
3. I feel confident studying science.
4. I use science in my everyday life.
5. People with good social skills tend to become scientists.
6. I do not mind if I have to work hard to understand scientific concepts.
7. People should understand science because it affects their lives.
8. Scientific work is useful to everyone.
9. I may not make great discoveries, but working in science would be fun.
10. Science should be a required part of everyone's education.
11. Science is essential for the continued vitality of society.
12. I like to learn about new scientific discoveries.
13. There are job possibilities in the Toledo area that require some science training.
14. I might consider a career that involves science
15. Science affects the lives of people in the Toledo area.
16. It is important to protect our environment.
17. Using renewable energy sources is an important part of protecting our environment.
18. Renewable energies create jobs in the Toledo area.

LEADERS University Faculty Inventory

Your responses to the following questions will help us to better understand your role in the LEADERS Math-Science Partnership. There are no correct responses.

1. What subjects do you teach?

2. Describe what you think the typical science lesson might look like in:

Grades 3 -5

Grades 6 -8

High school

3. What do you believe are the science education needs of our local K-12 schools?

4. How do you think K-12 schools might benefit from working with university STEM faculty?

5. Over the past year, how frequently have you collaborated on science education or science issues with the following (check the box that best represents your level):

	Never	Once or twice a year	Quarterly	Monthly	Weekly	Daily
University faculty in other departments						
Teachers in K-12 schools						
Science-related businesses and industries						

6. How might you as a University of Toledo faculty member interact with K-12 schools to improve science instruction and learning?

LEADERS Business/Industry Partner Inventory

Your responses to the following questions will help us to better understand your role in the LEADERS Math-Science Partnership. There are no correct responses.

1. What type of organization do you represent?

2. Describe what you think the typical science lesson might look like in:

Grades 3 -5

Grades 6 -8

High school

3. What do you believe are the science education needs of our local K-12 schools?

4. How do you think K-12 schools might benefit from working with area science-related businesses and industries?

5. Over the past year, how frequently have you and/or your organization collaborated on science education or science issues with the following (check the box that best represents your level):

	Never	Once or twice a year	Quarterly	Monthly	Weekly	Daily
University STEM faculty						
Teachers in K-12 schools						
Other science-related businesses and industries						

6. How might you and/or your organization interact with K-12 schools to improve science instruction and learning?