EAGR: Building Tools for Creating Coherence Across Evaluations of Schoolyard LTER Programs

Final Report
November 30, 2011

Steven McGee (mcgee@lponline.net), Randi McGee-Tekula, and Jennifer Duck
The Learning Partnership

1 Introduction

The Schoolyard LTER program (sLTER) was formally established in 1998 through supplemental funding from the Division of Environmental Biology. For twelve years through 2010, each LTER site received annual funding supplements upon request, $24,000 in 2010, to design their own program in relation to the ecological research conducted at the site and in light of the particular needs and resources of the local school districts and communities. The sLTER program has provided an infusion of resources for LTER sites to develop and pilot test a diverse array of education activities and programs. This site autonomy has fostered tremendous creativity and has resulted in a wide array of programs for local and national audiences. At the same time, the plethora of programmatic approaches makes it challenging to draw general conclusions about the sLTER program as a whole without a centralized coordination of evaluation activities.

The Learning Partnership, under the direction of Steven McGee (LUQ), has conducted an inventory of the sLTER programs implemented during the 2009-2010 school year. This inventory was developed through an analysis of published materials on each site's sLTER web site as well as from interviews conducted with 21 of the 26 sLTER coordinators. An interview protocol was developed to collect information about the strategies that sites used to impact students and teachers, the extent to which these strategies align with best practices and leverage LTER site science, the approximate reach of the site's sLTER activities, and the extent to which the sites have secured additional funding to extend the reach of their sLTER (see Appendix A for the protocol).

The protocol for curriculum materials was drawn from recently released National Research Council reports: *Ready, Set Science* (Michaels, Shouse, & Schweingruber, 2008) and *Surrounded by Science* (Fenichel & Schweingruber, 2010). Both reports emphasize that there are key strands of learning that should be supported through every science experience. These science strands are: spark interest and excitement, help students understand scientific content and knowledge, engage students in scientific reasoning, help students reflect on the process of science, engage students with the tools and language of science, and help students identify with the scientific enterprise.

The interview protocol for student research activities was based on a framework of successful citizen science programs developed at the Cornell Lab of Ornithology (Bonney, Cooper, et al., 2009). The primary components are identifying a research question that aligns with the site science, providing validated protocols for collecting data, providing training in the use of the protocols, supporting data submission, data analysis, and dissemination of results.

The protocol for teacher professional development was based on a national evaluation of the Eisenhower National Clearinghouse professional development program (Garet et. al. 2001). Garet and his colleagues found that effective professional development involves a substantial amount of contact hours over a long span of time. It is helpful when teachers from the same school participate in the professional development together. The professional development experience should focus on specific content, should allow teachers time to practice the targeted set of skills, and should provide opportunities for the teacher to develop implementation plans. The professional development should be coherent with the teachers' ongoing professional development, be aligned to standards and assessments, and provide a means for teachers to build a professional community.

The framework for the Research Experiences for Teachers was based on the Columbia University Summer Research Program for teachers (Silverstein, Dubner, Miller, Glied, & Loike, 2009) and a five-year evaluation of engineering RET site grants conducted by SRI International (Russell & Hancock, 2007). The primary components are providing extended research experiences over more than one summer, supporting the development of long-term relationships between teachers and researchers, providing explicit support and guidance for teachers on how to transfer what they have learned to the classroom and that teachers participate in research that matches the subject they are teaching in school.

The interviews took place from July to September of 2010. The resulting inventory characterizes the extent to which the site activities align with best practices and leverage LTER site science, approximates the reach of the site's sLTER activities, and estimates the extent to which the sites have secured additional funding to extend the reach of their sLTER. The results of the interview process are used to address the following evaluation questions:

1. How many students and teachers were involved in Schoolyard LTER programs in 2009-2010?
2. To what extent was additional funding for student and teacher programming leveraged in 2009-2010 from NSF's annual investment in the Schoolyard programs?
3. Did the strategies impacting students align with the best practices identified from the research literature?
4. Did the strategies for impacting teachers align with the best practices identified from the research literature?
5. In what ways did the student and teacher programs take advantage of the unique long-term research at each site?

1.1 Summary of Recommendations

In aggregate the twenty-one sites who participated in the interview process reported that they served **1,355 teachers** and **40,918 students** during the 2009-2010 school year. This section provides a summary of the recommendations that emerged from the analysis of interview data and the alignment to best practices. The subsequent sections provide more detail about the evidence to support these recommendations.

1.1.1 Curriculum

- The sLTER network should develop and maintain an electronic repository of sLTER curriculum materials. This repository would enable sharing of resources across sites and facilitate consistency in addressing the strands for learning.
- In conjunction with the electronic repository, the sLTER network should establish a peer review process for curriculum materials to be deposited in the repository. The peer

review process would ensure that materials align to the goals of LTER research and ensure the quality of the materials to be included. In addition, the peer review process would encourage the site coordinators to develop a common framework for the development of curriculum materials.

1.1.2 Student Research Experiences

- The sLTER network should identify or develop online tools to support the submission, display and analysis of student-collected data.
- The sLTER network should explore ways to host a network-wide symposium for student research. The GLOBE Learning Expedition is one example of an on site experience[1]. It may also be possible to host a virtual symposium.

1.1.3 Professional Development

- sLTER sites should consider developing long-term partnerships with targeted school districts. This would enable the sLTER sites to recruit groups of teachers to participate together and to better align their professional development programs to the needs of teachers.
- sLTER sites should consider alterations to the professional development scheduling to be able to offer professional development over longer time spans, without necessarily increasing the amount of contact hours. This would enable teachers to practice what was learned in between professional development sessions and reflect on that implementation at subsequent workshops.

1.1.4 Research Experiences for Teachers

- Based on SRI's findings and recommendations, NSF should require that proposals for LTER RET supplements should describe a follow-up plan, and proposals for LTER RET supplements in subsequent years should provide documentation of such follow-up from previous years.
- Based on SRI's findings and recommendations, NSF should encourage PIs to focus strongly on making the summer experience relevant to participants' K-12 classrooms by selecting only those participants whose classroom subjects are directly related to the RET research area(s) and providing adequate time, financial support, and assistance to enable participants to translate their research experiences to their classrooms.
- Similar to the recommendations under professional development and based on SRI's findings and recommendations, sLTER sites should consider developing long term partnerships with school districts. In the context of RET, sLTER sites should accept teachers in pairs from the same school district and allow them to participate for at least two summers.

2 Inventory of Programs

The Learning Partnership developed an inventory of the sLTER programs implemented during the 2009-2010 school year. The inventory was developed through an analysis of published materials on each site's sLTER web site as well as from interviews conducted with 21

[1] http://classic.globe.gov/fsl/html/templ.cgi?gle_general&lang=en

of the 26 sLTER coordinators. Each activity was placed in one of six categories. Three of the categories focused on student programs: curriculum materials, student research experiences, and field trips. The other three categories focused primarily on teachers: professional development, Research Experiences for Teachers, and implementation support. In aggregate the twenty-one sites reported that they served **1,355 teachers** and **40,918 students** during the 2009-2010 school year.

The first set of evaluation questions we sought to answer was: What strategies have sites used for impacting students? How many students and teachers are reached by the sLTER student activities? To what extent do sites secure additional funding to support sLTER student activities? Table 1 below shows the distribution of sites that conducted each of the student programs during the 2009/2010 school year, the average number of students and teachers reached per site and the percentage of sites that leveraged the schoolyard funds to secure additional funding. Two-thirds of the twenty-one sites interviewed indicated that they provide support for student research either on site or at the school. Almost two-thirds of the sites indicated that they have developed and disseminated curriculum materials. Just over one third of the sites indicated that they support school field trips to the site. Three of the sites indicated that they do not support any student activities, choosing primarily to focus on providing support for teachers. The vast majority of the sLTER sites have leveraged the schoolyard LTER funds to secure additional funding to implement student programs.

Student Programs	**Sites**	**Teachers Per site**	**Students per site**	**% Leverage**
Support for Student Research	14	26	1341	79%
Curriculum	13	31	483	62%
Field Trips	8	114	3684	88%
Total	**18**	**63**	**2214**	**71%**

Table 1: Distribution of sLTER programs targeted at students

The second set of evaluation questions we sought to address was: What strategies have sites used for impacting teachers? How many teachers are reached by the sLTER teacher activities? To what extent do sites secure additional funding to support sLTER teacher activities? Table 2 below shows the distribution of sites that conducted each of the teacher programs during the 2009/2010 school year. Over eighty percent (81%) of the sites indicated that they conduct professional development activities. Over forty percent (43%) of the sites provided Research Experiences for Teachers (RET) in which teachers spend time at the LTER site conducting LTER research. During the school year, teachers are expected to incorporate what they have learned from the research experience into their classrooms. Almost twenty percent (19%) of the sites provide implementation support in the form of site visits by sLTER staff or scientists. All of the sites have at least one type of program to support teachers. The vast majority of the sites that conduct professional development have leveraged the sLTER funds to secure additional funding. Sites were less likely to leverage sLTER funds to secure funding for the RET program and for implementation support. The majority of the sites fund RET teachers through the annual sLTER RET supplements.

Teacher Programs	Sites	Teachers Per site	% Leverage
Professional Development	17	41	88%
Research Experiences for Teachers	9	2	33%
Implementation Support	4	4	25%
Total	**21**	**34**	**61%**

Table 2: Distribution of sLTER programs targeted at teachers

3 Alignment of Student Programs to Best Practices

As part of the interview process, the site coordinators were asked to describe their student programs. The interview protocol prompted the site coordinators to address specific elements of the best practices framework for each type of student program. Below are reviews of the alignment of sLTER curriculum materials and sLTER student research experiences to their respective best practices frameworks. Following each review are recommendations on ways to strengthen sLTER support for curriculum and student research experiences.

3.1 Curriculum

Thirteen of the sites indicated that they have developed curriculum materials based on LTER research. On average, 31 teachers and 483 students at each site use these curricula. These curricula span grades kindergarten through twelfth grade and address a wide range of topics found across the LTER network — animals, plants, biodiversity, climate, soil, weather, invasive species, response to disturbance and urban environments. There are a variety of ways that the curricula take advantage of the unique research conducted in LTER. Some of the curricula provide access to data collected by LTER scientists. Some provide summaries of research conclusions. Some have students follow similar protocols for data collection.

Developers use a range of strategies for organizing the sequence of activities. Some of the curricula linked the modules to specific time points such as the seasons of the year or planned social exchanges. Some of the curricula organized the modules around the standards students are expected to learn. Some organized the modules in order of increasing complexity. Lastly, some curricula provide a collection of activities and have no specific sequence.

The sLTER sites use a variety of channels for disseminating the curricula. Some sites disseminate through partner organizations that work with teachers and students. Some sites provide the curricula as part of their professional development program. Some sites disseminate the materials through presentations at science teacher conferences. Others provide access to the materials online or rely on word of mouth.

Since the curriculum materials were developed based on a wide range of curriculum models, such as 5E (Bybee, 1997) and cognitive apprenticeship (Collins, Brown, & Newman, 1989), it is not possible to come up with one framework that can be used to review how well the curriculum development initiatives at sLTER sites are following best practices. Instead, we used two recent National Research Council reports on formal (Michaels, et al., 2008) and informal (Fenichel & Schweingruber, 2010) science education to identify six strands of learning that all science education activities should strive to address. Each site described how they were supporting the strands of learning. Below is a description of the range of approaches that have been taken by the sLTER curriculum development initiatives.

The first strand is *sparking interest and excitement*. Curriculum materials should help students experience "excitement, interest, and motivation to learn about phenomena in the natural and physical world." Most of the sites reported that the nature of the phenomena generates interest and excitement. The work of sLTER is often outdoors and often involves charismatic species. There is also a cyclical nature to the phenomenon (e.g., students can write letters when birds migrate and then receive letters when the birds return). LTER research is localized and often involves authentic problems, such as threats to plants or hurricane disturbance. Some of the curricula use program elements that are known to spark interest, such as exploration (Dennen, 2004), fantasy (Parker & Lepper, 1992), and interactivity (Malone & Lepper, 1987).

The second strand of learning is *understanding scientific content and knowledge*. Curriculum materials should help students in "generating, understanding, remembering, and using concepts, explanations, argument, models, and facts related to science." In order to make LTER science accessible to the classroom, curriculum projects focus on the connection between LTER science concepts and the science standards students are expected to learn. Without a connection to the standards, teachers would not be able to fit the LTER activities into their school curriculum. After aligning LTER concepts to the standards, there are two main strategies that sLTER curriculum projects used to support the understanding of scientific content. First is supporting students in applying scientific concepts to environmental decisions (Edelson, 2001). Second is sequencing activities in such a way as to support cognitive growth (Bybee, 1997; Collins, et al., 1989).

The third strand of learning is *engaging in scientific reasoning*. Curriculum materials should help students in "manipulating, testing, exploring, predicting, questioning, observing, and making sense of the natural and physical world." Many of the curriculum projects support students in conducting fieldwork such as monitoring invasive species or measuring environmental variables. Some sites engage students in virtual fieldwork by having students take simulated measurements on virtual transects. In addition to collecting field data, some curriculum projects support students in analyzing data through techniques such as modeling and model validation.

The fourth strand of learning is *reflecting on science*. Curriculum materials should help students in "reflecting on science as a way of knowing, including the processes, concepts, and institutions of science. It also involves reflection on the learner's own processes of understanding natural phenomena and the scientific explanations for them." Two of the curriculum projects mentioned explicit support for helping students reflect on the unique nature of science. One project helps students compare the difference between scientific reasoning based on evidence and everyday decision making based on opinion. The other project has students examining the impact of science on managing our environment.

The fifth strand of learning is *using the tools and language of science*. Curriculum materials should engage students in "participation in scientific activities and learning practices with others, using scientific language and tools." sLTER curriculum projects encourage the use of scientific vocabulary and highlight the uniqueness of the scientific meaning of everyday terms, such as explanation. Some sites also support in depth use of scientific tools such as modeling.

The sixth strand of learning is *identifying with the scientific enterprise*. Curriculum materials should help students to think of themselves "as a science learner and developing an identity as someone who knows about, uses, and sometimes contributes to science." The primary means by which sLTER sites support students in identifying with the scientific enterprise is by providing students with successful experiences of engaging in scientific inquiry (McGee, 2008). In addition, several sites present students with career information and highlight LTER scientists.

In conclusion, the collection of curriculum materials as a whole address all six of the strands of learning. However, the sLTER sites seem to be the strongest in sparking student interest, supporting the understanding of scientific content and knowledge, and engaging students in scientific reasoning. Fewer sLTER projects explicitly focus on supporting reflecting on science, using tools and language of science, and helping students identify with the scientific enterprise. For the most part, sLTER sites have independently developed their curriculum materials. The network may gain consistency and benefits in fostering collaboration around the development and dissemination of sLTER curriculum materials. The following are recommendations on how the sLTER network can better support alignment to the strands of learning:

- The sLTER network should develop and maintain an electronic repository of sLTER curriculum materials. This repository would enable sharing of resources across sites and facilitate consistency in addressing the strands for learning.
- In conjunction with the electronic repository, the sLTER network should establish a peer review process for curriculum materials to be deposited in the repository. The peer review process would ensure that materials align to the goals of LTER research and ensure the quality of the materials to be included. In addition, the peer review process would encourage the site coordinators to develop a common framework for the development of curriculum materials.

3.2 Student Research Experiences

For decades the Cornell Lab of Ornithology has successfully engaged the general public to participate in research on birds (Bonney, Cooper, et al., 2009). The lab currently has almost a dozen different citizen science opportunities. Thousands of volunteers submit tens of millions of observations each year. Studies have shown that participants in citizen science have increased their scientific knowledge, their abilities to engage in scientific inquiry, and spend more time observing in nature. Two-thirds of the sLTER sites seek to achieve similar outcomes by providing opportunities for students to participate in LTER student research experiences. On average, 26 teachers support and 1341 students participate in student research experiences at each site. The primary recommendations for best practices in engaging students in research are identifying a research question that aligns with the site science, providing validated protocols for collecting data, providing training in the use of the protocols, supporting data submission, data analysis, and dissemination of results.

The first recommendation is to develop scientific questions that are consistent with the LTER research at each site. All of the sites have students engage in research that is related to the LTER site research. Almost three-fourths of the sites that support student research provide students with the research question to investigate, either in their schoolyard or at the LTER site. Projects that provide the research question and the means to investigate the question are considered contributory since students are contributing to an existing research project (Bonney, Ballard, et al., 2009). Several of the sites allow for co-created research projects in which the participants and the scientists develop research projects together. The sLTER program at Luquillo has common research questions that students contribute to, but schools are also supported in developing school specific research questions that complement the common research questions. At Andrews and Konza Prairie the individual teachers develop school specific research questions. The sLTER programs at Florida Coastal Everglades and Virginia Coastal Reserve support high school interns in developing their own questions.

The second recommendation is to provide students with validated protocols that have been tested and refined. These protocols should be supported by instruction booklets or web sites. All of the sites that support contributory projects provide students with protocols for collecting their scientific data. Half of the sites that support contributory projects provide educational materials and a web site to support the validated protocols. One notable example is the Ecoplexity.org web site. It is an NSF-funded collaboration of four of the sites that support contributory research projects (Jornada, Luquillo, Central Arizona, and Andrews). Short Grass Steppe is a fifth sLTER site that collaborated on Ecoplexity, but did not participate in the site interviews. On the other hand, those sites that support either school specific or student specific research are not able to provide validated protocols ahead of time.

The LTER sites should provide training for participants on the process of science in general and where applicable training on specific protocols. Nine of the ten sites that support contributory projects provide training to teachers (6 sites) or students (3 sites) on the use of specific protocols. These workshops provide teachers or students with hands on experience in using the protocols to collect data. In contrast, Andrews and Konza Prairie provide teachers with training on general research methods related to the LTER site science. Florida Coastal Everglades and Virginia Coastal Reserve provide students with direct mentoring on research methods.

The sLTER sites that support contributory projects should accept, edit, and display the data that teachers and students collect. Nine of the ten sites provide some form of support for accepting and editing the data. At four of the sites the participants complete paper records of the data and provide those records to the site coordinator who enters the data. At two of the sites, students enter the data in Excel spreadsheets, which are then submitted electronically to the sites. Three of the sites have developed databases or electronic templates for students to directly enter the data. In all cases, the data is available for downloading, but currently there are no tools for displaying the sLTER data.

The LTER sites should provide support to analyze and interpret data. None of the sites provide explicit online tools for analyzing and interpreting the data. Eight of the ten sites that support contributory research provide some form of support for analysis of data. Two of the sites include analysis as part of the training that teachers receive. Teachers are given the opportunity to use Excel to analyze the data. Four of the sites provide direct mentoring to teachers in how to analyze their data. Two of the sites provide spreadsheet templates for students to compute basic descriptive statistics and comparisons.

LTER sites should provide students and teachers with opportunities to disseminate the results of their research. Five of the fourteen sites that support LTER student research provide support for disseminating the results of their research. Four of the sites host an annual symposium for students to share their results with other students conducting the same LTER research. The Florida Coastal Everglades provides support for students to submit their research to the science fair. Rather than host students directly, teachers at Harvard Forest workshops present the results of their students' research to other teachers attending workshops of the data protocols. These presentations serve to provide examples of how students have used the Harvard Forest data.

In conclusion, the sLTER sites that support student research experiences take advantage of the unique LTER science and engage students with research questions that align to site research. Most of the sites that support research also provide validated protocols and provide training in the use of the protocols. The sites are mixed on the availability of instructional support materials. The sites are also mixed on the support provided to submit data. Only a handful of sites offer a technological system for submitting data. Once the data are submitted, the sites tend not to have strong support for analyzing data and disseminating results. The following are recommendations on how sLTER student research experiences can better align to best practices in citizen science:

- The sLTER network should identify or develop online tools to support the submission, display and analysis of student-collected data.
- The sLTER network should explore ways to host a network-wide symposium for student research. The GLOBE Learning Expedition is one example of an on site experience[2]. It may also be possible to host a virtual symposium.

4 Alignment of Teacher Programs to Best Practices

As part of the interview process, the site coordinators were asked to describe their teacher programs. The interview protocol prompted the site coordinators to address specific elements of the best practices framework for each type of teacher program. Below are reviews of the alignment of sLTER professional development and sLTER Research Experiences for Teachers to their respective best practices frameworks. Following each review are recommendations on ways to strengthen sLTER support for professional development and Research Experiences for Teachers.

4.1 Professional Development

Garet and his colleagues (2001) developed an empirical framework that characterizes best practices in professional development. The framework is based on the results of a national survey of a sample of over one thousand attendees of Eisenhower Professional Development programs in 348 districts. The study results indicate that professional development that is long in duration, promotes collective participation, is focused on core content, involves active learning, and is coherent will most likely lead to increased teacher knowledge and changes in teaching practice. Over three-fourths of the LTER sites provide professional development to an average of 41 teachers as part of their Schoolyard LTER program. The interviews with the site coordinators provided insight on the extent to which the professional development provided by sLTER program has these characteristics.

As whole, the sLTER sites were strongest in the focus on content and in promoting portions of the active learning framework. All of the sites indicated that they focus on core scientific content related to their LTER research through active learning. During the workshops teachers engaged in the inquiry-based activities that they are expected to do with their students. They are also provided an opportunity to develop plans for how they would implement the lessons in their classroom. In addition to aligning the content of the workshops to LTER science, the professional development activities are aligned to state science standards and assessment frameworks.

[2] http://classic.globe.gov/fsl/html/templ.cgi?gle_general&lang=en

The sLTER sites are mixed in their implementation of other portions of the Garet framework. The framework indicates that longer duration workshops, both in terms of contact hours and span of time for the activities, are more effective. About 40% of the sites indicated that their professional development is long in duration. Most of the other sites tend to provide summer professional development that varied from one day to two weeks, but was short in time span. The Garet framework suggests that having groups of teachers participate together, embedding workshops within teachers' ongoing professional development, and providing teachers an opportunity to practice implementing the lessons and getting feedback on their implementation are most likely to lead towards changes in teaching practice. Only a handful of sites indicated that they actively recruited groups of teachers to participate and/or sought to align the workshop activities with the ongoing professional development needs of the participants. Most of the sites recruited broadly through listservs, web sites, and district offices. It was assumed that the professional development met the needs of the participants since the workshops are voluntary. None of the professional development programs provided teachers with the opportunity to implement lessons with students and get feedback on their implementation. The following are recommendations on how sLTER professional development can better align to best practices identified by Garet et. al. (2001):

- sLTER sites should consider developing long-term partnerships with targeted school districts. This would enable the sLTER sites to recruit groups of teachers to participate together and to better align their professional development programs to the needs of teachers.
- sLTER sites should consider alterations to the professional development scheduling to be able to offer professional development over longer time spans, without necessarily increasing the amount of contact hours. This would enable teachers to practice what was learned in between professional development sessions and reflect on that implementation at subsequent workshops.

4.2 Research Experiences for Teachers

Since the mid-1990's, researchers at Columbia University have conducted the Columbia University Summer Research Program for teachers. The main features of the program are two eight-week summer research experiences on the campus of Columbia University mentored by a faculty member, weekly seminars during the summer, financial support to transfer what is learned into the classroom, and support of a graduate student to aid in the transfer of concepts to the classroom. A longitudinal evaluation of teachers who participated in the program found that of the students taught by participating teachers, the percentage of students who passed the Regents exam increased by 10% points over a three-year period (Silverstein, et al., 2009).

Similarly, researchers at SRI International conducted an evaluation of Research Experiences for Teachers site projects over a five-year period. They correlated a host of teacher outcomes to key features of RET sites. Their findings indicate higher teacher outcomes were associated with longer research experiences over more than one summer, and the development of long term relationships between teachers and researchers (Russell & Hancock, 2007). Teachers were much more likely to transfer what they learned during the summer experience to the classroom if the research site provided explicit support and guidance for teachers on how to transfer what they have learned and that teachers participate in research that matches the subject they are teaching in school.

There were ten sLTER sites that indicated they hosted RET teachers in 2010 with an average of two teachers per site. Most of the sites (80%) provided extended research experiences of four weeks or more over one summer. None of the sites reported explicitly providing teachers with the opportunity to participate in multiple summers. All of the sites indicated that that they primarily recruited teachers with whom they already have a prior relationship connection to the program, such as having participated in previous workshops or previously worked with LTER scientists at the site. A handful of sites (30%) indicated that they also recruit teachers via listservs. Just over half of the sites (60%) indicated that teachers were matched with a scientist to serve as a mentor. At the remaining sites, the teachers worked with the sLTER coordinator. Only half of the sites (50%) reported providing explicit support for teachers to transfer what they have learned to the classroom. This support came in the form of time during the summer experience to develop curriculum materials, help securing equipment to replicate studies in the classroom, participation in school year workshops, and summer and school year mentoring from the sLTER coordinator. None of the sites reported explicitly matching teachers' research to the subject they teach in school. Given that the limitations of the sLTER RET programs are consistent with the limitations that SRI found in their evaluation of engineering RET site programs, the recommendations for the sLTER RET program mirror SRI's recommendations about site RET's (Russell & Hancock, 2007, p. 51):

- Based on SRI's findings and recommendations, NSF should require that proposals for LTER RET supplements should describe a follow-up plan, and proposals for LTER RET supplements in subsequent years should provide documentation of such follow-up from previous years.
- Based on SRI's findings and recommendations, NSF should encourage PIs to focus strongly on making the summer experience relevant to participants' K-12 classrooms by selecting only those participants whose classroom subjects are directly related to the RET research area(s) and providing adequate time, financial support, and assistance to enable participants to translate their research experiences to their classrooms.
- Similar to the recommendations under professional development and based on SRI's findings and recommendations, sLTER sites should consider developing long term partnerships with school districts. In the context of RET, sLTER sites should accept teachers in pairs from the same school district and allow them to participate for at least two summers.

5 Future sLTER Evaluation Work

The review of sLTER activities during the 2009/2010 school year provides a picture of the range of sLTER activities occurring across the network, the estimated reach of the sLTER network activities, and the alignment of sLTER activities to best practices. Given the budget for the project, the focus was on self-report of activity by the site coordinators. It was not possible to collect data directly from program participants to address the following evaluation questions about program impact:

1. What impact do the sites' teacher programs have?
   - 1a. What are teachers' perceptions of the professional development?
   - 1b. What are teachers' perceptions of the program they learned about in professional development?

1c. Do teachers implement the programs they learned about?

2. What impact do the sites' student programs have?
   2a. What ecological content and process skills do students learn?
   2b. Do students increase their enjoyment of science?
   2c. Do students increase their interest in pursuing science as a career?

This review has provided structure to the range of sLTER activities and through the best practices frameworks has identified potential strengths and weaknesses in terms of impact on program participants. It is now possible to develop specific hypotheses and collect data on how program features of sLTER activities will impact program participants. NSF should consider funding the next phase of the evaluation effort to develop and pilot test instrumentation that can be used to answer the evaluation questions above at the network level. To that end, The Learning Partnership has undertaken pilot work to build an infrastructure for ongoing data collection once the instrumentation has been pilot tested and validated.

5.1 Learning Monitor

The Learning Partnership is developing an open access online assessment system called the Learning Monitor. The system is set up as a test bank of science questions and science assessments for teachers to assign to their students. With funding from this project, we have prototyped modifications to the system to include teacher surveys and to provide support for sLTER sites to manage their evaluation data, while at the same time be able to aggregate the evaluation data across the network. The Learning Partnership has leveraged this project to secure funding from the U.S. Department of Education to complete the prototype. We anticipate that the system will be fully operational in time to roll it out at the All Scientist Meeting in September 2012.

The Learning Partnership has banks of surveys that can be used for evaluating STEM education activities for teachers and students. These surveys include teacher surveys on workshop satisfaction, satisfaction with the targeted program, and implementation surveys. Student surveys include ecosystems content assessment, attitudinal surveys, and career interest surveys. In order to be effective at addressing sLTER evaluation questions, these surveys should be customized for sLTER network-wide use, pilot tested, and validated. It will also be necessary to get input from all of the site coordinators so that the surveys are beneficial for local evaluation purposes. To the extent that the evaluation instruments serve local purposes, they are more likely to engender high quality data collection that will benefit the network at the aggregate level.

5.2 Science Standards

In order to support the development of common student assessments, the sLTER sites will need a common framework that can be used as a reference point across different state standards. The Integrative Science for Society and the Environment (ISSE) Framework, Figures 3.2 and 3.3 in the Decadal Plan, provides such a framework. Since it drives the network level research, aligning outreach activities and assessments to the framework will ensure that the activities focus on core LTER content and can be utilized across the network. However, in order for schools to be able to take advantage of the resources and assessments, it will be important for them to be aligned to the local state standards. The Learning Partnership has determined that all of the LTER sites are contained within 18 states. We have downloaded the high school science standards from each of these states and have aligned each of the relevant science standards in the

18 states to the ISSE framework. Therefore, for activities aligned to standards in one state, we can use the ISSE framework to show the alignment of the activity to standards in a different state. This framework will enhance the capability of sites to share their educational resources across states as well as provide a common infrastructure for assessing student understanding in such a way that it can be tied to local outcomes as well as be aggregated at the network level.

6 References

Bonney, R., Ballard, H., Jordan, R., McCallie, E., Phillips, T., Shirk, J., et al. (2009). *Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education*. Washington, DC: Center for Advancement of Informal Science Education. Retrieved November 28, 2011 from http://caise.insci.org/uploads/docs/PPSR%20report%20FINAL.pdf.

Bonney, R., Cooper, C. B., Dickinson, J., Kelling, S., Phillips, T., Rosenberg, K. V., et al. (2009). Citizen Science: A Deveioping Tooi for Expanding Science Knowiedge and Scientific Literacy. *BioScience, 59*(11), 977-984.

Bybee, R. W. (1997). *Achieving Scientific Literacy*. Portsmouth, N.H.: Heinemann.

Collins, A., Brown, J. S., & Newman, S. (1989). Cognitive apprenticeship: Teaching the crafts of reading, writing, and mathematics. In L. Resnick (Ed.), *Knowing, Learning, and Instruction: Essays in Honor of Robert Glaser* (pp. 453- 494). Hillsdale, NJ: Lawrence Erlbaum Associates.

Dennen, V. P. (2004). Cognitive Apprenticeship In Educational Practice: Research On Scaffolding, Modeling, Mentoring, And Coaching As Instructional Strategies. In D. H. Jonassen (Ed.), *Handbook of Research on Educational Communications and Technology (Second edition)* (pp. 813-828). Mahwah, NJ: Lawrence Erlbaum Associates.

Edelson, D. C. (2001). Learning-For-Use: A framework for the design of technology-supported inquiry activities. *Journal of Research in Science Teaching, 38*(3), 355-385.

Fenichel, M., & Schweingruber, H. A. (2010). *Surrounded by Science: Learning Science in Informal Environments*. Washington, DC: National Research Council.

Garet, M. S., Porter, A. C., Desimone, L., Birman, B. F., & Yoon, K. S. (2001). What makes professional development effective? Results from a national sample of teachers. *American Educational Research Journal, 38*(4), 915-945.

Malone, T. W., & Lepper, M. R. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. In R. E. Snow & M. J. Farr (Eds.), *Aptitude, Learning, and Instruction* (Vol. 3, pp. 223-253). Mahwah, N.J.: Lawrence Earlbaum Publishers.

McGee, S. (2008). *Looking Beyond Academic Achievement for Inspiring the Next Generation*. Paper presented at the Annual meeting of the American Educational Research Association, New York, NY. Retrieved November 29, 2011 from http://www.lponline.net/papers.html.

Michaels, S., Shouse, A. W., & Schweingruber, H. A. (2008). *Ready, Set, Science!* Washington, DC: National Research Council.

Parker, L. E., & Lepper, M. R. (1992). Effects of Fantasy Contexts on Children's Learning and Motivation: Making Learning More Fun. *Journal of Personality and Social Psychology, 62*(4), 625-633.

Russell, S. H., & Hancock, M. P. (2007). *Evaluation Of The Research Experiences For Teachers (RET) Program: 2001-2006*. Menlo Park, CA: SRI International. Retrieved November

23, 2011 from http://www.sri.com/policy/csted/reports/university/documents/RET3_Final_Report_07.pdf.

Silverstein, S. C., Dubner, J., Miller, J., Glied, S., & Loike, J. D. (2009, October 9). Teachers' Participation in Research Programs Improves Their Students' Achievement in Science. *Science, 326,* 440-442.

APPENDIX A: Interview Protocol for Schoolyard LTER Coordinators

Prior to the Interview:

1. Provide the site representative with the list of K-12 activities by category that we gleaned from their web site, ASM survey, and annual report. Let them know we will ask them to correct the list of activities and their categories. They can send a corrected list ahead of time or that can be done during the interview.
2. Let them know we will be asking for artifacts of the various activities (e.g., program guides, curriculum materials, protocols, workshop agendas)
3. Provide the site representative with a copy of the Strands of Science Learning and Strategies for Support Learning.

Overview Questions:

1. Interview Consent: The purpose of the interview process is to document the nature, extent, and success of the activities for each site's K12 Schoolyard Program. We will summarize the interview and release a report to NSF and the general public with the details that are provided during the interview. Therefore, do not share details that you do not want made public.
2. Who is involved in the Schoolyard LTER program? (names of people)
    a. What is each person's role?
    b. What is each person's background?
    c. What percentage of each person's time is devoted to the Schoolyard program and how is that time funded?
3. What role do the site scientists play in the Schoolyard Program?
4. Does the site conduct education research and/or evaluation?
    a. Can they send a list of reports?
5. Does the site have long-term relationships with schools or districts?
6. Make corrections to the list of Schoolyard LTER activities. Note any projects that comprise multiple activities.

For each **teacher professional development** activity:

1. Can they send an agenda or other artifacts?
2. From summer 2009 to end of school year 2010, how many teachers participated in the workshop?
3. What were the general demographics of the teachers (e.g., elementary, middle school, or high school; minority population, gender focus)?
4. How was each workshop funded? If from other than Schoolyard Supplement, who funds it and what is the approximate level of additional funding?
5. How much contact time was there over what time span?

6. How were participants recruited? Were teachers from the same school encouraged to participate together?
7. What was the core content of the workshop? How does that leverage the unique, long-term research at the site? Was the workshop in support of some other project (e.g., curriculum, student data collection)?
8. Describe the general format of the workshop.
    a. Did teachers practice the targeted content or skills?
    b. Did teachers have a chance to plan for their implementation?
    c. Did teachers get practice implementing the lessons during the workshop?
    d. How was feedback provided to the teachers?
9. Coherence
    a. How was the workshop embedded within the teachers' ongoing professional development?
    b. How was the workshop aligned to state standards or assessments?
    c. What tools were available for teachers to continue to communicate with each other after the workshop?

For each **research experiences for teachers** program:

1. From summer 2009 to end of school year 2010, how many teachers participated in RET?
2. What are the general demographics of the teachers (e.g., elementary, middle school, or high school; minority population, gender focus)?
3. How was each RET funded? If from other than Schoolyard Supplement, who funds it and what is the approximate level of additional funding?
4. How long did the teachers spend conducting research?
5. How were participants recruited?
6. How did the teachers come up with the research projects? What research did they do? How did the research experience leverage the unique research at the site?
    a. Can they send final reports?
7. How was the teacher supported in incorporating the experience back into the classroom?
8. Is there anything else you would like to tell us about the RET program at your site?

For each **curriculum** project:

1. From summer 2009 to end of school year 2010, how many teachers and students implemented the curriculum?
2. What are the general demographics of the teachers and students (e.g., elementary, middle school, or high school; minority population, gender focus)?
3. How was development funded? If from other than Schoolyard Supplement, who funded it and what was the approximate level of additional funding?

4. How is it disseminated? Is it supported by professional development?
5. How is implementation funded? If from other than Schoolyard Supplement, who funds it and what is the approximate level of additional funding?
6. What is the topic and grade level?
7. Describe the basic approach to scope and sequence?
8. How does the curriculum support the Strands of Science Learning?
    a. Spark interest and excitement
    b. Help students' understanding of scientific content and knowledge
    c. Engage students in scientific reasoning
    d. Help students reflect on science
    e. Help students use the tools and language of science
    f. Help students identify with the scientific enterprise?
9. How does the curriculum take advantage of the unique research being conducted at the site?
10. Can they send a copy of materials?

For each support for **student data collection** project (facilitated by the teacher):

1. From summer 2009 to end of school year 2010, how many teachers and students participated in collecting data?
2. What are the general demographics of the teachers and students (e.g., elementary, middle school, or high school; minority population, gender focus)?
3. How is the project funded? If from other than Schoolyard Supplement, who funded it and what was the approximate level of additional funding?
4. What protocols are supported?
5. What support is provided for asking research questions?
6. What support is provided for collecting the data?
7. What support is provided for submitting data?
8. What support is provided for analyzing data?
9. What support is provided for sharing the results of their research?
10. Is the data collection supported by a curriculum or professional development?
11. How are safety issues addressed?
12. How does the data collection activity take advantage of the unique research being conducted at the site?
13. Can they send a copy of the protocols?

For each **on-site student research** project (supported by LTER):

1. From summer 2009 to end of school year 2010, how many teachers and students participated in collecting data?
2. What are the general demographics of the teachers and students (e.g., elementary, middle school, or high school; minority population, gender focus)?

3. How is the project funded? If from other than Schoolyard Supplement, who funded it and what was the approximate level of additional funding?
4. What protocols are supported?
5. What support is provided for asking research questions?
6. What support is provided for collecting the data?
7. What support is provided for submitting data?
8. What support is provided for analyzing data?
9. What support is provided for sharing the results of their research?
10. How does the research experience support the Strands of Science Learning?
    a. Spark interest and excitement
    b. Help students' understanding of scientific content and knowledge
    c. Engage students in scientific reasoning
    d. Help students reflect on science
    e. Help students use the tools and language of science
    f. Help students identify with the scientific enterprise?
11. How are safety issues addressed?
12. How does the data collection activity take advantage of the unique research being conducted at the site?
13. Can they send copies of materials provided to students?

For each **field trip or site visit** to LTER site (supported by LTER):

1. From summer 2009 to end of school year 2010, how many teachers and students participated in field trips?
2. What are the general demographics of the teachers and students (e.g., elementary, middle school, or high school; minority population, gender focus)?
3. How were the field trips funded? If from other than Schoolyard Supplement, who funded it and what was the approximate level of additional funding?
4. What was the focus of the field trips?
5. How did the field trips support the Strands of Science Learning?
    a. Spark interest and excitement
    b. Help students' understanding of scientific content and knowledge
    c. Engage students in scientific reasoning
    d. Help students reflect on science
    e. Help students use the tools and language of science
    f. Help students identify with the scientific enterprise?
6. What strategies were used to support learning from the informal activity?
    a. Juxtaposition?
    b. Multiple modes?
    c. Interactivity?
7. How are safety issues addressed?
8. How does the field trip take advantage of the unique research being conducted at the site?
9. Can they send copies of materials provided to students?