GLOBE YEAR 9 EVALUATION

IMPLEMENTATION SUPPORTS AND STUDENT OUTCOMES

Prepared by SRI International for The GLOBE Program

May 2005
P12125

Authors:
William R. Penuel
Marie Bienkowski
Christine Korbak
Andres Molina
Dana Russo
Linda Shear
Yukie Toyama
Louise Yarnall

With assistance from:
Amy Lewis
Bowyee Gong
Emily Vinson

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Introduction

SRI International (SRI) prepared this evaluation research report for the GLOBE Program. This is the second report submitted under the new grant to SRI for the GLOBE evaluation and the ninth in a series of annual evaluation reports SRI has provided to the GLOBE Program since its inception. GLOBE continues to evolve as a program. Although GLOBE's central mission has not changed, the Program's administration, methods for preparing teachers, and strategies for promoting expansion have all changed since its inception. We begin this report, as we have in the past, with an overview of the Program and critical steps in its evolution in the 2003–04 year.

The Year 9 evaluation report (covering the school year 2003–04) describes GLOBE Program growth and studies of GLOBE partner organizations, and it provides reviews of GLOBE materials (the Teacher's Guide), supplementary materials such as videos, and the GLOBE Web site. The report also presents positive results of a study of achievement of students learning with GLOBE. These parts of the GLOBE evaluation provide data to stakeholders that demonstrate the value GLOBE provides.

Overview of GLOBE and Developments in 2003–04

Earth Day 2004 marked GLOBE's 10th year as a program, an important milestone and sign of the Program's continued reach in the world. In addition, in fall 2004, GLOBE was recognized by the Goldman Sachs Foundation by being awarded its Prize for Excellence in International Education. The reason the Program was selected highlights what many view as the Program's chief contribution to science and education and reason for its longevity. GLOBE's reach is worldwide, spanning more than a hundred countries, and it brings the world into the classroom through the power of technology. GLOBE seeks to motivate educators to participate by engaging them and their students in the process of scientific inquiry. In fall 2003, GLOBE passed the 10 million measurement mark: GLOBE students had taken 10 million measurements that follow protocols developed for the Program to monitor Earth's systems. By fall 2004, that number had increased to just under 12 million.

Since its inception in 1994, GLOBE has been unique in its dual identity as an environmental science and education program. GLOBE scientists seek to enhance their understanding of the Earth by conducting research in four major investigation areas: Atmosphere, Hydrology, Soils, and Land Cover. They also conduct research on interactions among phenomena in each of these investigation areas to construct models of Earth as a system. The scientists in GLOBE, however, depend on students in classrooms to collect and report the data they use in their investigations. GLOBE's regional partners around the world recruit, prepare, and provide support to educators to enable them to implement GLOBE with their students. GLOBE educators see the Program as providing their students with opportunities to *do science*, and GLOBE scientists benefit directly from student involvement in the Program.

Gathering Community Input

The 2003–04 school year was a transition year for Program administration. At the beginning of the year, NASA began its contract with the University Corporation for Atmospheric Research (UCAR) and Colorado State University (CSU) to take over management of GLOBE. As part of its efforts to manage a smooth transition, the UCAR/CSU partnership has been committed to gathering input in the past year in a variety of ways: meetings with individual partners and country coordinators, group meetings of partners and scientists, and large meetings with different stakeholders from the community. These meetings have been facilitated by UCAR and CSU staff, and reports of larger meetings have been posted on the GLOBE Web site.

One of the most important meetings was a community meeting in January 2004 to gain input from scientists, educators, and researchers who have been part of GLOBE over the years. At the meeting, the community discussed the diverse reasons for participating in GLOBE, GLOBE's place in science and education, the Program's strengths and weaknesses, and opportunities for strengthening the Program. Work plans and a new structure for partnership support were also reviewed by the community at the meeting. In addition, NASA presented the outlines of a draft of its Earth science education plan, which was released in summer 2004.

Reorganization of Partner Support into Regions

An important development in 2003–04 was the reorganization of partner support. GLOBE's international partners are now organized into regions, and a GLOBE staff member supports each region. In addition, regions have been encouraged to develop their own structures and activities to support their work, with the technical assistance of the Program. At this year's annual conference, regions were given time to meet and develop a range of action plans to realize the vision of creating stronger regional GLOBE networks.

Technology is a critical component of support for regional work and participation in regional activities. On Earth Day in 2004, two regional networks had GLOBE Web chats. Students from the Middle East who had been studying Land Cover, Atmosphere, and Climate discussed water chemistry online. Students from the greater Caribbean region shared their student research and experiences in GLOBE. This chat included students who wrote in English and Spanish; translation was provided in real time to facilitate participation.

Continuation of GLOBE ONE

During 2003–04, the new UCAR/CSU team took over administrative oversight of the GLOBE ONE field campaign. GLOBE ONE is a project that brings all of GLOBE scientists together to focus on a single set of research questions that can be investigated by using data collected in a single region, northeastern Iowa. Both students in the area and automated stations are collecting data as part of the study, which was initiated in early 2003, when GLOBE Headquarters was still in Washington, DC, in an effort to help increase the opportunities for scientists to publish research based on GLOBE data. The new leadership of GLOBE took an active role in helping to shape and refine the project. Chief Scientist Peggy LeMone, supported by staff member John McLaughlin, has helped guide scientists and provided technological infrastructure to help advance the project's goals.

GLOBE ONE represents a new kind of model for GLOBE science-education partnerships. Although field campaigns are not new to environmental science, and Chief Scientist Peggy LeMone has been part of several, they are new to GLOBE. They represent an opportunity for scientists to work more closely with a selected group of classrooms on a topic of local interest. The work is intensive rather than extensive, providing students with much more exposure to GLOBE protocols and learning activities. It does not require GLOBE implementation to be sustained, which many schools have found difficult to do. As such, GLOBE ONE is a promising model for the future of GLOBE. SRI is conducting case studies of the collaborative project to document its progress, challenges, and successes.

New Online Learning Opportunities for Partners

In spring 2004, GLOBE launched a new Trainer Certification Program (TCP) for U.S. partners. The TCP combines face-to-face workshop time with online learning opportunities to expand potential new trainers' opportunities to learn about GLOBE while making it more convenient to participate. The TCP includes a prerequisite online Orientation course, a face-to-face workshop, and a postrequisite online Practicum course to provide additional support and learning opportunities. GLOBE Partners nominate potential trainers for participation in the TCP, and participants are required to take part in all aspects of the Program.

GLOBE offered the first TCP training sequence in spring 2004. The focus of the training was on weather and climate. The subject matter focus is significant because the training was organized by a topic that is part of many teachers' curriculum, rather than organized by investigation area. Multiple protocols from across a wide range of investigation areas were being taught as part of the TCP course, but the topic of weather and climate served as a unifying theme. A common thread in the instruction was also the concept of the Earth as a system. Three different sections of this course were offered in 2003–04.

NASA's New Education Goals and GLOBE

The NASA Earth Science Enterprise (ESE), released in June 2004, is a plan for Earth science education that is designed to "inspire the next generation of Earth explorers." NASA takes a broad view of Earth explorers as ranging from elementary students to researchers and hobbyists. Earth exploration at NASA is made possible by the range of Earth-observing satellites.

NASA's belief is that study of the Earth forms a compelling context for all students, especially underserved students, to engage in science, technology, engineering, and mathematics (STEM) education and learn about the Earth as a system. Goals of the ESE include having students learn more about both Earth system science and related careers. Initiatives are generally, although not always, tied to NASA missions or research programs. In education, ties are forged to other science areas, such as physics, chemistry, biology, mathematics, engineering, and technology. The ESE's major themes are understanding Earth as a *system*, teaching science through inquiry-based activities, and using visualization to investigate Earth systems data. The ESE sees online learning (or "E-education") as an enabler for its mission.

There are several ways in which GLOBE's goals and activities are well aligned with the new plan. Remote observations of the Earth align closely with the on-ground observations of the type made by GLOBE students, and they enable NASA to study Earth as a system and predict Earth system changes. The ESE focuses on prediction in its study areas: climate variability and change, atmospheric composition, carbon cycle and ecosystems, water and energy cycle, weather, and Earth surface and interior. GLOBE's different investigation protocols focus on many of these areas. Online learning is now being explored more systematically within the TCP, another area of close alignment with NASA's vision for education.

In its approach to supporting ESE learning, NASA's plan relies on its digital information infrastructure to deliver resources and on a network of partners to help with the insertion of

ESE courses into existing educational activities. Vast quantities of geospatial data sets are produced and reformatted to be usable by educators. Digital libraries, such as NSF's Digital Library for Earth science education, afford this access. However, even at this global scale of the Earth, NASA still sponsors education activities that concentrate on issues facing a geographic community, as in its REASoN (Research, Education, Applications, Solutions Network) projects. Thus, GLOBE, is well aligned with NASA's goals for Earth science education, (Table 1-1).

Table 1-1. NASA Education Themes and GLOBE Practices

NASA Theme	Operating Principle	GLOBE Practices
Customer focus	Respond to a need.	Serve the science and education community.
Content	Use NASA content to involve learners in Science, Technology, Engineering, and Mathematics (STEM).	Focus on hand-collected data and Earth system concepts.
Pipeline	Emphasize workforce-related programs to encourage STEM careers.	Provide access and visibility to GLOBE science principal investigators (PIs) which puts a human face on science careers.
Diversity	Reach identified targeted groups.	Leverage underserved groups' connections with the land and their community.
Evaluation	Document outcomes and demonstrate progress toward goals.	Conduct descriptive and assessment-oriented evaluations every year.
Partnerships/ Sustainability	Leverage partners for sustainability of programs.	Implement the Program around a partner model.

Year 9 Evaluation: Major Research Questions and Activities

Year 9 was the first year in which SRI's evaluation work was conducted under the new GLOBE management. SRI worked jointly with GLOBE at UCAR to develop the following list of evaluation questions and methods for answering them. Some activities are (and have been) carried out every year, such as the Program growth review. Other activities are the focus of a specific year's evaluation, such as the achievement study and the materials review. The partner survey will become an annual activity, conducted initially by SRI and carried forward by UCAR in future years. Its results are not reported here, because of an insufficient response rate. However, data from the survey will be used in conjunction with teacher survey data to be collected in Year 10.

Five questions emerged from SRI's discussions with GLOBE management. These are largely addressed in the evaluation covered in this report, with the exception of a teacher study, a broader achievement study, and a case study of the GLOBE ONE learning community in Iowa all to be conducted in Year 10.

Question 1: How is GLOBE growing, in terms of teachers trained and data reported?

The new GLOBE team has plans for revamping the teacher training to include a longer time span for the training and more online learning. Documenting the Program growth each year can tell us about the data reporting levels, and how growth correlates with other factors.

Question 2: What do successful partners do that makes them successful?

To understand success, we conducted case studies of successful partners in Alaska, Alabama, Idaho, and Iowa. These partners were chosen because they have trained large numbers of teachers who go on to implement GLOBE.

Question 3: How do teachers find and use different GLOBE-developed materials, such as the Teacher's Guide, when they implement the Program?

An in-depth interview was conducted with a sample of GLOBE teachers to ascertain how they use the GLOBE Teacher's Guide and the GLOBE Web site, and to discover which resources they find most helpful. The results are intended to provide the Program with additional data to improve its materials, including the Teacher's Guide and Web site.

Question 4: How do teachers experience and implement GLOBE?

Through evaluation activities planned for Year 10, we seek to deepen our understanding of what protocols and learning activities teachers implement, and to understand especially the role of professional development experiences in shaping implementation. On the basis of data/feedback, we also will explore from a diverse sample of teachers who have been trained in recent years, what barriers exist to implementing GLOBE

Question 5: What is the effect of GLOBE on student achievement?

Since 1995, SRI's evaluation activities have examined some aspect of GLOBE's effects on students' learning in science. In our investigations, we have relied on assessments of our own design, rather than on standardized measures of science achievement. Many of our assessment items are similar to standardized test items, but they are focused on concepts that are actually taught as part of GLOBE. Our aim in using our own measures has been to provide evidence from evaluation data based on *instructionally sensitive* assessments, that is, tests that would be able to detect changes in student learning brought about by participation in GLOBE. As part of these studies, we have documented positive effects of GLOBE on student knowledge, perception of the environment, and problem-solving skills. In Year 9, we conducted a quasi-experimental study of GLOBE learning in eight classrooms; for Year 10, we have planned a study that will include 50 classrooms that uses a comparison-group design.

Organization of the Report

This report is organized into four main chapters that report on data from separate substudies in the Year 9 evaluation. Each of the chapters addresses one or more of the themes of this year's evaluation: implementation supports for teachers or student outcomes. Implementation supports include not only teachers' initial training, which provides them with the basic knowledge and skills to implement GLOBE, but also activities undertaken by partners and materials teachers use to support classroom implementation. Outcomes, for purposes of this report, are analyzed in terms of students' gains on a test of student knowledge and inquiry skills in the Hydrology investigation area.

Chapter 2 reports on Program growth with respect to new teachers trained and data reporting. The two indicators are important, if imprecise, indicators of how much the Program is growing in reach. Additional indicators reported here are the number of schools that persist in data reporting from year to year (an index of retention) and the number of schools who are on the GLOBE honor roll (an index of implementation quality).

Chapter 3 reports on results from case studies of two of GLOBE's more successful U.S. partners. The chapter describes how these partnerships were selected, methods used in collecting data, and results of the study. Implications for the potential role of partners as intermediary organizations supporting local science education reform are also discussed in this chapter.

Chapter 4 describes the results of a small pilot study of how teachers use GLOBE's different Web-based and print curriculum materials to support implementation. Teachers' choices of materials to use with students, as well as their difficulties with using them with students, are the focus of the analysis.

Chapter 5 reports on the results of a quasi-experimental study of learning in GLOBE. The chapter describes the classrooms that were the context for the study, the instruments used, and the overall results, including effects on conceptual knowledge and attitudes toward science.

Chapter 6 presents conclusions and recommendations based on the Year 9 evaluation substudies.

Program Growth

The GLOBE Program completed its 9th year during the 2003–04 school year. The Program's reach remains at a stable level, with decreases in activity in some areas and increases in others. The number of teachers trained in the United States shows an increase over 2002–03, but teachers trained internationally decreased. The number of schools reporting data decreased in Year 9, as did the number of data reports by schools, which showed the same slight decline as in previous years.

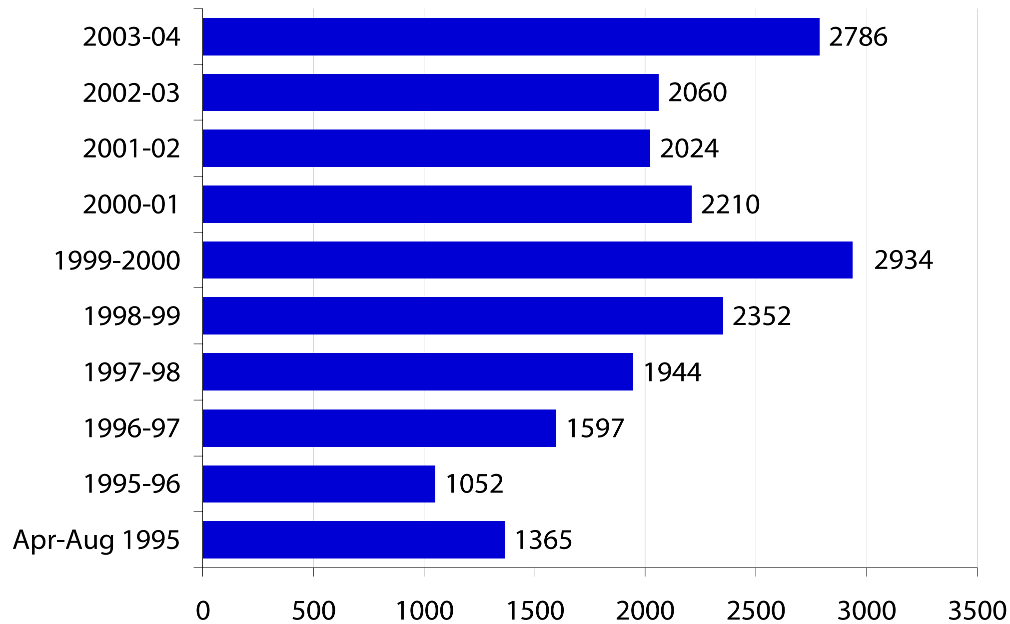
Data Sources for Growth Indicators

This chapter reports data from GLOBE records of the number of teachers trained and from the GLOBE Data Archive. It is important to note that these are imprecise indicators of Program growth because teachers trained do not always implement GLOBE, or they might implement protocols without reporting data. As a result, there is not a direct relationship between training and data reporting and there is not a predictable impact on data reporting clearly attributable to training. Similarly, because data reporting often lags behind training and data collection, the Data Archive may not reflect all of the GLOBE activities in which schools and students have engaged. At the same time, these figures can provide a rough estimate of a chief "input" to GLOBE and driver of growth for GLOBE: teachers who are new to the Program.

Number of Teachers Trained

At first glance, it appears that there has been an overall increase in the number of teachers trained in 2003-04 compared with 2002-03 (Figure 2-1). However, the increase is due to training done by only one partnership. GLOBE in Alabama trained 1019 teachers in 2003-04 as a result of their partnership with a statewide program, the Alabama Math, Science, and Technology Initiative (AMSTI). GLOBE in Alabama will continue to receive funding through this program and will train more teachers than in the past in the next few years. Aside from the increase in the number of teachers trained in Alabama, the number trained nationwide was similar to 2002-03. The lack of increase in teachers trained is most likely attributable to two factors reflected in the partner survey conducted in 2003: partners are focusing their efforts on providing support to trained teachers rather than training new teachers, and partners are finding their previous sources of funding for training have disappeared without replacement (Penuel, Korbak, Yarnall, Lewis, Toyama, & Zander, 2004).

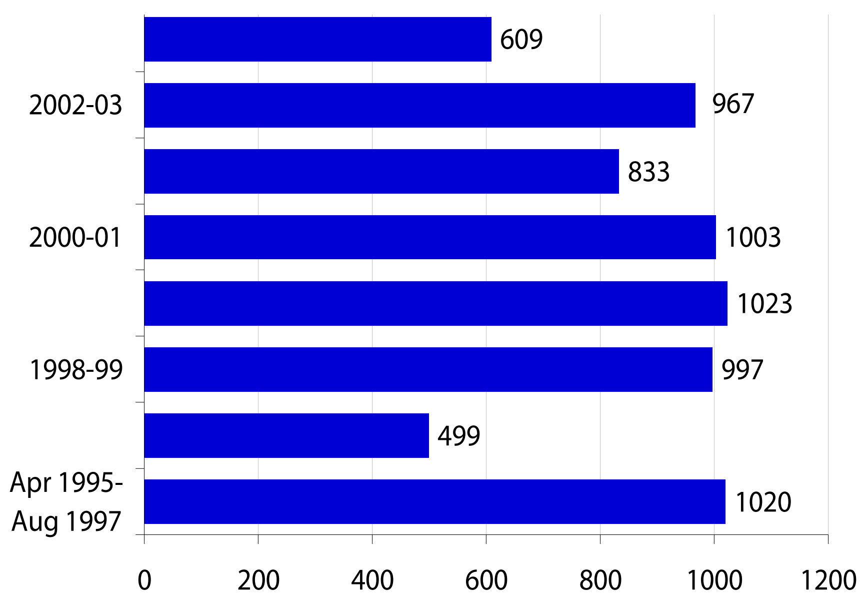
Figure 2-1. Number of Teachers Trained in the United States, by Year*



** Bars depict 12-month (September-August) training totals, except as noted in 1995.*

There was a decrease in the number of teachers trained internationally. Teachers trained internationally decreased by 37% from 2002–03 to 2003–04 (Figure 2-2). This represents the lowest number of GLOBE teachers trained internationally since 1997-98.

Figure 2-2. Number of Teachers Trained Internationally, by Year*



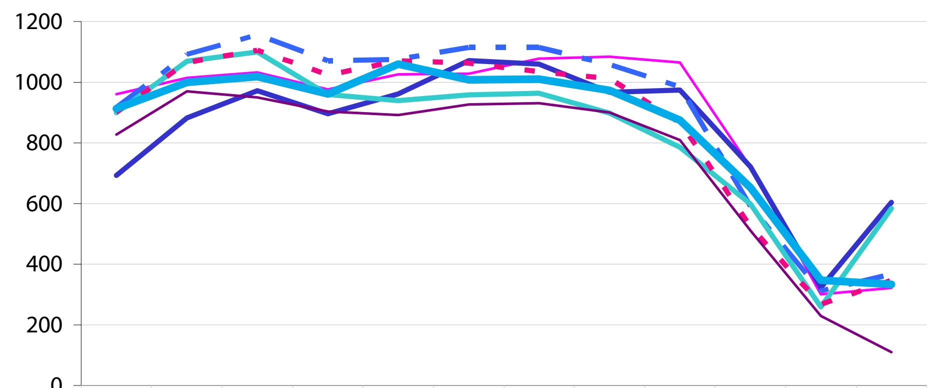
** Bars depict 12-month (September-August) training totals, except as noted in 1995–97.*

Trends in GLOBE Data Reporting

Data reporting is a "lagging indicator" of implementation, since teachers often do not begin to report data until 6 to 8 months after initial training; however, it is an important indicator because scientists need data for their investigations. On this indicator, there was a decrease in the total number of schools reporting data: 1,623 in 2003–04, compared with 1,893 in 2002–03 and 1,848 in 2001–02

In 2003-04, the number of schools that reported GLOBE data by month continued to follow the pattern seen in previous years (Figure 2-3). Data reporting rose in the fall and maintained a relatively stable level through the early spring, then began a steep decline in May as the school year came to an end. As in recent years, there was a sharper decline earlier in the spring than there was in the initial years of the Program, in all likelihood because of increased pressures placed on schools to focus on preparation for standardized tests in reading and mathematics. However, in 2003–04, there was not a rising trend after July, and schools reporting data continued to decline through August.

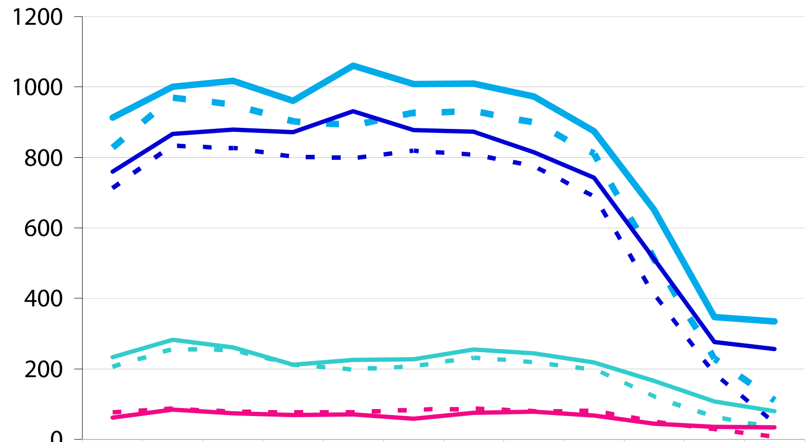
Figure 2-3. Number of Schools Reporting Data Overall, by Month and Year



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
1997-98	960	1014	1032	976	1026	1028	1078	1084	1065	720	301	322
1998-99	692	882	972	896	961	1071	1060	967	974	721	323	604
99-2000	916	1091	1156	1070	1075	1115	1115	1058	985	591	311	367
2000-01	899	1069	1100	959	939	958	964	898	785	598	259	584
2001-02	900	1065	1105	1024	1070	1063	1034	1012	867	523	267	346
2002-03	913	1000	1018	961	1060	1008	1010	973	875	652	347	334
2003-04	827	970	950	903	892	927	931	900	810	511	229	110

As in previous years, the investigation area with the highest rate of data reporting continued to be Atmosphere, followed by Hydrology (Figure 2-4). Reporting in three investigation areas, Atmosphere, Hydrology, and Soil, remained stable during 2002–03 and 2003–04. For all investigation areas, except for Soil, reporting data in 2003–04 seemed to be lower than in 2002–03. The biggest gap in data reporting between years was in Atmosphere, especially during January (14% decrease in data reporting), July (33% decrease), and August (82% decrease). The number of schools reporting Hydrology data remained fairly stable during the academic year, except for a decrease in reports from June to August, and showed little variation from 2002–03 to 2003–04. Soil was the investigation area with the most stable reporting throughout the year. There was a slight increase in the number of schools reporting Soil measurements between Year 8 and Year 9 from September to June. However, Soil continued to be the investigation area with the lowest number of schools reporting data on (fewer than 100 schools for all months considered).

Figure 2-4. Number of Schools Reporting Data in Years 8 and 9, by Investigation Area

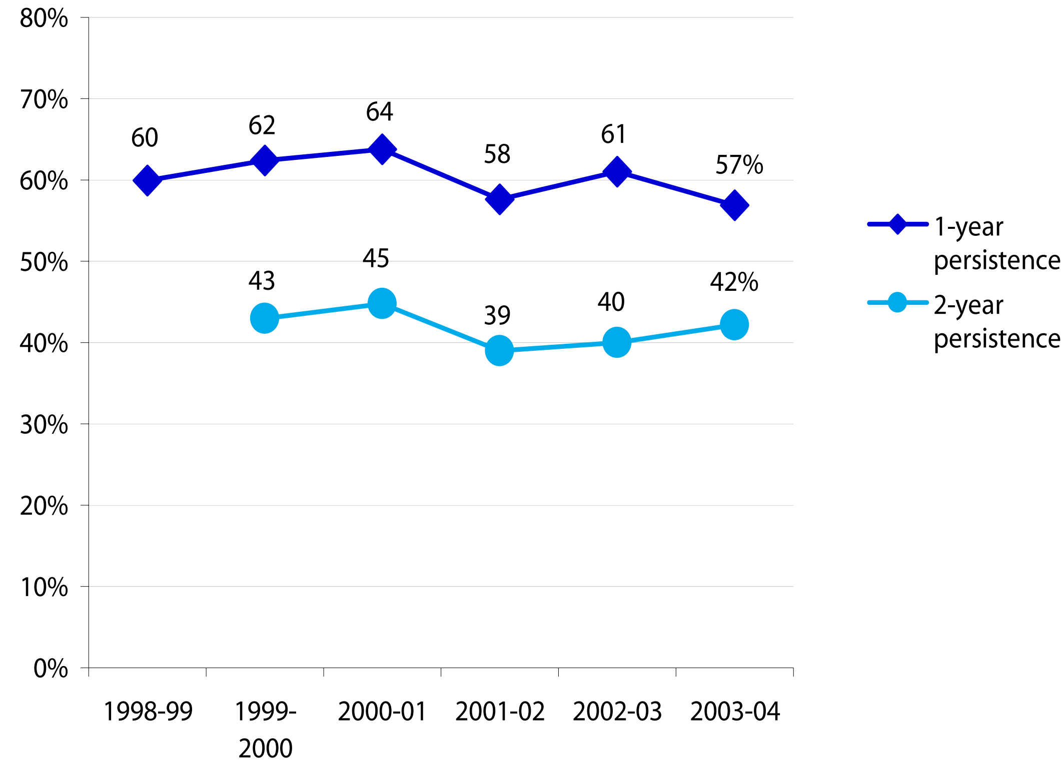


	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
All reports 2003-04	827	970	950	903	892	927	931	900	810	511	229	110
All reports 2002-03	913	1000	1018	961	1060	1008	1010	973	875	652	347	334
Atmos 2003-04	712	834	827	803	798	819	808	775	689	412	184	47
Atmos 2002-03	760	867	880	872	932	877	873	815	742	512	276	256
Hydro 2003-04	206	256	253	212	198	207	231	219	198	121	63	34
Hydro 2002-03	234	283	261	211	226	227	255	244	218	165	108	80
Soil 2003-04	77	88	79	77	76	84	88	80	82	50	29	7
Soil 2002-03	62	84	73	69	71	58	75	78	67	44	35	34

Reporting Persistence and Schools Reporting for the First Time

Persistence in data reporting from year to year by GLOBE schools is necessary if data collected are to be used in exploring variation in Earth systems. Therefore, SRI began reporting persistence in data reporting in 2000–01. Initially, the rate of persistence in data reporting increased slightly each year (Figure 2-5) for both schools that reported 2 years in a row (1-year persistence) and those that reported 3 years in a row (2-year persistence). In Year 7 (2001–02), the persistence rates decreased. In Year 8 (2002–03), both the 1- and 2-year persistence rates increased, but the increase for 2-year persistence was very small (0.6%). In Year 9, 1-year persistence decreased to the lowest point since 1998–99. However, 2-year persistence has been increasing since 2001–02, reaching 42% in year 2003–04. This pattern suggests that while the percentage of teachers who stay committed to GLOBE over longer periods of time is increasing, the number of teachers who tried GLOBE out 2 years ago (perhaps for the first time) but did not continue in 2003–04 increased. The result is a higher attrition rate for first-time reporters but more steady commitment from teachers who report data over multiple years.

Figure 2-5. Percentage of Schools Reporting Data Persistently, by Year

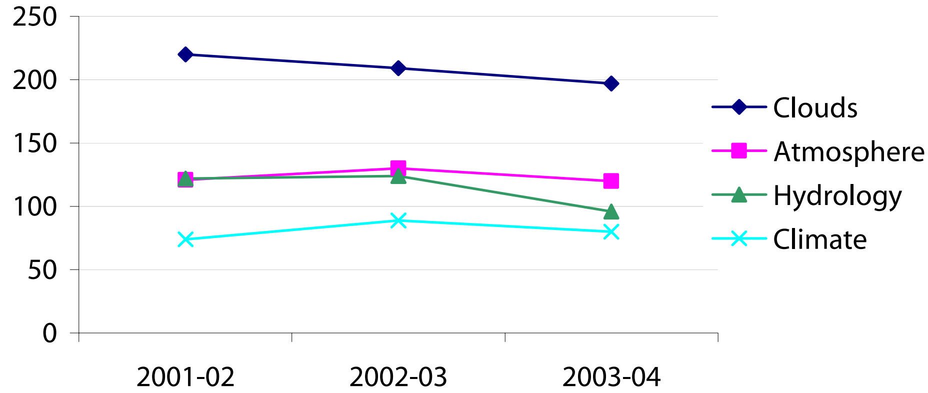


Number of Schools on the GLOBE Honor Roll

Schools are named to the honor roll for an investigation area if the data they report meet the standards for data reporting for that area. The standards reflect the quality requirements, such as number of data points over time, that will allow scientists to make use of GLOBE data in their research. Although there are many reasons why all schools may not be able to meet honor roll standards, it is important to the GLOBE Program that a proportion is able to do so. Ideally, the number of schools on the honor roll for each investigation area should show a relationship to the number of schools reporting data. That is, if the number of schools reporting data increases greatly, the number of schools on the honor roll would ideally increase, as well.

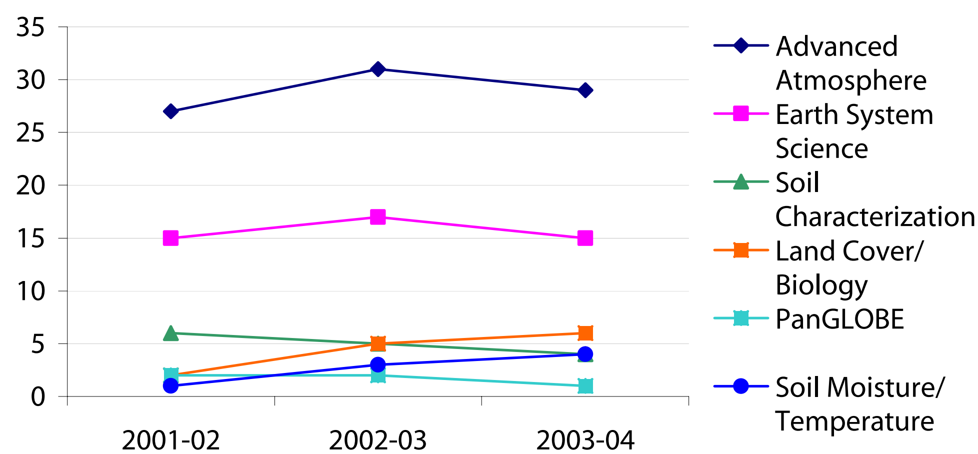
For the most commonly implemented investigation areas, the number of schools on the honor roll did not increase from 2002-03 to 2003-04 (Figure 2-6). The number of schools decreased for Clouds and for Hydrology but remained relatively stable for Atmosphere and Climate.

Figure 2-6. Number of Honor Roll Schools for Most Commonly Implemented Investigation Areas



For other investigation areas (Figure 2-7), the number of schools making the honor roll increased (Land Cover/Biology, Soil Moisture/Temperature), decreased slightly for a second year (Soil Characterization, PanGLOBE), or remained relatively steady for a third year (Advanced Atmosphere, Earth System Science). The Soil Moisture and Temperature protocol's continued rise may reflect the strong involvement of a science principal investigator (PI) in supporting this level of data reporting. This particular PI, moreover, is also a GLOBE partner. This science-education collaboration is a model for other scientists to potentially replicate, where possible.

Figure 2-7. Number of Honor Roll Schools for Other Investigation Areas



Discussion

Data reporting patterns continue to reflect a stabilizing of the overall number of teachers implementing GLOBE. On the one hand, more than 2700 new teachers were trained in 2003-04. At the same time, the overall level of data reporting for the most commonly implemented protocols declined slightly from 2002–03 to 2003–04. A close examination of the 1- and 2-year persistence in data reporting rates revealed that there was an increase in "one-time" GLOBE implementers. The percentage of teachers who reported one year and then the next declined from 61% in 2002–03 to 57% in 2003–04. At the same time, GLOBE seems to be fairly effective in maintaining a core group of teachers who implement the Program over multiple years. In fact, the percentage of teachers who report multiple years has increased in each of the last 3 years.

The honor roll data provide further confirming evidence that GLOBE does a good job of supporting implementation among its most committed teachers. These schools' data reflect scientists' standards for the quantity of data needed for their own research, and they provide one measure of implementation quality that is independent of data reporting. The number of honor roll schools, of course, is much smaller than the number of total schools reporting. One metric the Program might consider adopting in the future as a measure of implementation quality is the percentage of all schools reporting by investigation area that meet the honor roll requirements.

Atmosphere and Hydrology remain the investigation areas for which most schools that implement GLOBE report data. Protocols in other investigation areas have gained little ground in recent years against the popularity of these protocols. The most likely explanation for this effect is the ease with which the protocols can be implemented and how readily they are mapped onto state standards for which teachers are responsible. Standards are becoming an increasingly important guide for teachers' selection of supplementary educational materials; as No Child Left Behind requirements in science are implemented in the coming years, tests are also likely to drive teachers' decisions as to what protocols to implement.

Partner Study

Reform Intermediaries as Catalysts of Change and Implementation

Beginning in the late 1990s, implementation research has increasingly focused on the role intermediary organizations or partners play in carrying out large-scale school reforms. Intermediary organizations are typically nonprofit companies, universities, or other entities that are not part of the K-12 school system but maintain school improvement as a key goal. Many schools now employ these organizations to provide professional development, inquiry-oriented curriculum materials[1], and teacher support in the implementation of school reform. Researchers have argued that intermediary organizations may be critical to the reform process because they can provide the knowledge, skills, and resources necessary to scale up reform efforts (Cohen, 2000; Fullan, 2000; McDonald, McLaughlin, & Corcoran, 2000).

Scaling up an educational reform or program is itself a difficult undertaking, and many successful educational reforms and programs rely on a network of affiliates or partners to help support this process (Elmore, 1996). Organizations that design and test new reforms may not have the necessary skills within their organization to shift from sheltered implementation in a few classrooms to the support of broad-scale implementation. Furthermore, while some organizations do have the skills, they are rarely large enough to support implementation beyond a limited geographical area. The costs to support a national or international program quickly exceed the resources typically allocated to educational programs and reforms. As with the adoption of new technologies in business, the scale-up process inevitably comes to depend on people and organizations outside the direct purview of the reform designers (Moore, 2002). Therefore, reliance on intermediary individuals and organizations may be not only desired, but also necessary if the goal of a reform is to scale up and reach many classrooms. Furthermore, as outsiders, intermediary organizations can be better positioned to pose challenging questions to entrenched interests within school systems that have historically blocked the implementation or scaling up of significant reforms.

For their part, teachers may need people from intermediary organizations to help them adapt new curricular materials to their own classroom situations. This may be especially true when the program or reform seeks to reach diverse national and international classroom contexts where the challenges teachers face vary tremendously. Despite scores of studies that point to evidence to the contrary, the idea that new programs and scripted teacher curricula can be made “teacher-proof” has been a persistent belief of some policy-makers in science education (Atkin & Black, 2003). In fact, teachers will always need to explore how a new reform fits into their existing curriculum, and adapt the reform to meet the unique demands of their classrooms, school, district, and state. As a result those providing local support should have a good understanding of the setting where teachers are expected to implement a reform and maintain relationships with both the designers of the reform and the teachers who enact it (Carpenter et al., 2004).

Neither these claims about the need for intermediaries nor claims about their functions in implementing reforms and programs have been systematically investigated in science

[1] By inquiry-oriented materials, we mean those designed to promote the understandings and abilities of inquiry as outlined in the National Science Education Standards (National Research Council, 1996, 2000).

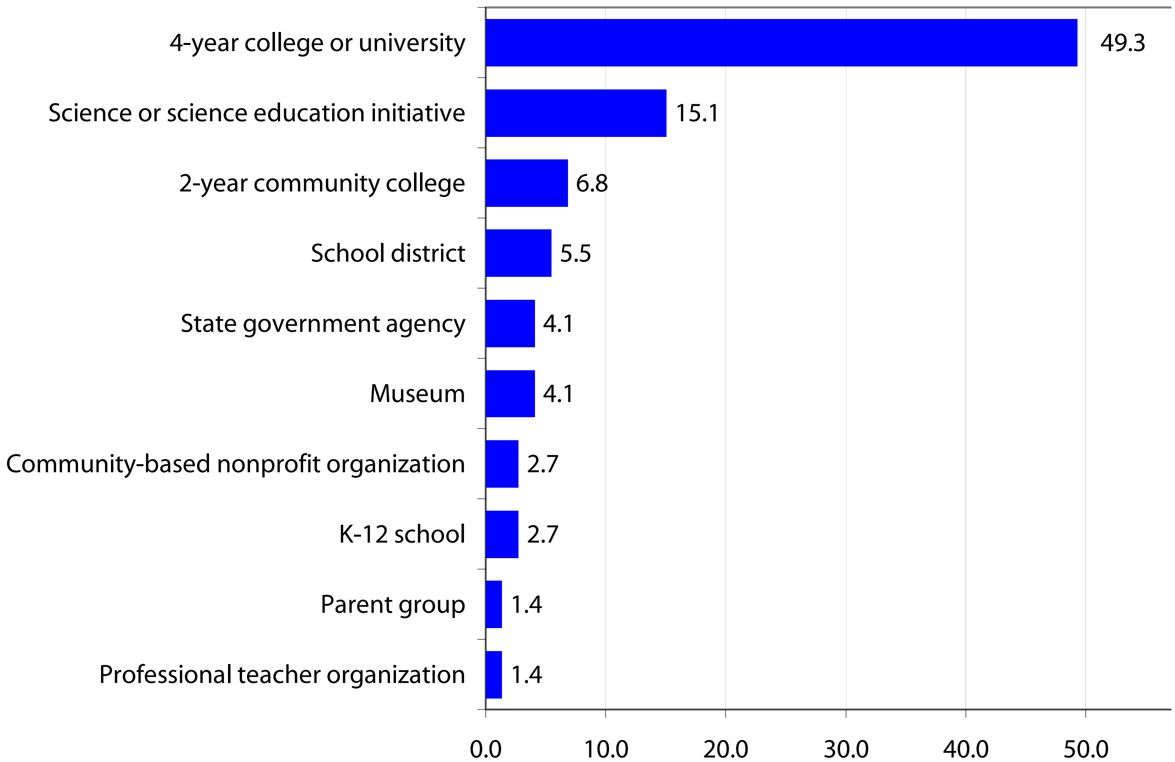
education. Even in studies of schoolwide reform, where the work of intermediaries has been closely studied, there remains little research on the capacity needed for such organizations to succeed or which strategies are needed to succeed (Neufeld & Guiney, 2000). This chapter investigates some preliminary hypotheses about the roles that intermediaries or partners can play in the GLOBE Program. By examining two partner case studies, we seek to offer a basis for a line of implementation research to help us better understand how to support reform in the field of international Earth science education.

Studying the GLOBE Program and Its Reform Intermediaries

In 1999, GLOBE instituted a program to engage regional GLOBE *partners* to recruit, train, and support GLOBE teachers on a local level. Since that time, the attention of partners and GLOBE Program staff changed focus from scaling up to another challenge: Program implementation at the school level. Despite the large numbers of trained GLOBE teachers, only about 1,000 schools report data to the GLOBE Data Archive each month, implying that only a small fraction of trained teachers are actively implementing the Program (Penuel et al., 2004). In addition, despite the Program's emphasis on students conducting their own investigations and research using GLOBE data, very few students have this opportunity (Penuel, Korbak, Lewis, Shear, Toyama, & Yarnall, 2003).

Partners have the primary responsibility for implementing strategies to improve these results since they function as intermediaries between GLOBE and teachers, acting as the local training and support arm for the Program. The partners are similar to reform intermediaries in other contexts in that they tend to be organizations outside the K-12 system that have as their mission the improvement of science education in schools. When describing benefits to participation in GLOBE, partners more often cite their involvement in helping to improve science teaching than their role in helping the Program to scale (Penuel et al., 2004). As Figure 3-1 shows, just less than half of partners who responded to a 2003 survey (N = 73) are housed within universities; of the partners in these settings, moreover, most are within colleges of education charged with teacher preparation.

Figure 3-1. Partner Organization Type, Percent Reporting from Partner Survey



Like many other intermediary organizations, GLOBE partners face the significant challenge of finding their own funding for their activities. The GLOBE Program includes a small staff that functions as partner support but does not fund partners directly for their activities. Partners generate financial resources from a variety of sources, including federal grants, foundation grants, state and local education agencies, and from sources within their own institutions (Means et al., 1999; Penuel et al., 2004).

In the United States, GLOBE partners from different regions share similar views of the chief obstacles facing them in their work of supporting GLOBE implementation. More than 72% of partners surveyed in 2003 said that a major challenge to their work was teachers' beliefs that implementing the Program conflicts with pressures to teach to state standards and perform well on accountability tests. In addition, more than two-thirds of U.S. partners surveyed suggested that more resources are needed to follow up with teachers after their initial training to help them overcome obstacles to implementation (Penuel et al., 2004).

As part of its evaluation of GLOBE, researchers at SRI's Center for Technology in Learning conducted a set of case studies to help explain differences in the accomplishments of GLOBE partners. Case studies were selected to study these differences, because as a research team, we were interested in investigating more deeply a finding from our survey research of a broad sample of GLOBE teachers, which identified several posttraining teacher support strategies that were associated with higher levels of data reporting (Penuel & Means, 2004). The focus of the case studies was further informed by alternative suggestions that have been articulated by different parts of the GLOBE organization (including partners) about how partners can address implementation problems. Throughout this chapter, we will refer to the reform intermediaries as partners or as GLOBE partners, since that is how they are known within the Program.

Design of the Case Studies

Goals

The study reported in this chapter seeks to replicate and extend findings from an earlier study about the importance of particular implementation support strategies carried out by partners. The earlier study found that some strategies—particularly providing mentoring, equipment, and supplementary materials—were all associated with higher levels of reporting GLOBE data (Penuel & Means, 2004). Through our case studies, we hoped to learn more about the nature and quality of the support provided to teachers and how teachers perceived those supports as helping them to implement GLOBE, as well as the challenges that partners face in their work and strategies for overcoming them.

Our purpose in selecting a case study approach was not to assess the prevalence of either particular strategies among GLOBE partners or the availability of supports from partners to individual schools. Rather, our goal was to test several hypotheses about partners' challenges and successes. By testing these hypotheses, we sought to increase understanding of the potential roles of reform intermediaries in an Earth science education program.

Design

We chose an explanatory multiple-case embedded design for this study (Yin, 2003). The purpose was to test rival hypotheses or explanations about the success of particular strategies of teacher support used by partners and about the capacity needed to carry them out. The primary unit of analysis is the *partnership* (the organization run by the partner), with its own mission, structure, staffing pattern, and organizational context; selected teachers were examined as embedded units of analysis "belonging to" the partnership.

Two partner cases form the basis of the analyses conducted for this chapter. The two cases were selected, as indicated below, because both were active and visible to teachers and to GLOBE as significant intermediary organizations. However, they are in quite different geographical areas, serve different kinds of schools, and have different organizational structures. We describe below the similarities of the two cases as well as their differences in individual teachers' involvement with partner activities that were critical in selecting case study sites.

Each of the case studies is treated here as if it is a "whole" study, in which evidence is analyzed with respect to the hypotheses of the study. In this respect, our view of case study research is consistent with Yin's (2003): we view each case's conclusions as needing to be replicated by evidence from other individual cases. These particular findings call for not only further replication within GLOBE but also replication within other kinds of Earth science programs with different designs and teacher supports. Many Earth science programs share with GLOBE several features that make them challenging to implement: field-based research that may require the establishment of data monitoring stations outside the classroom; Internet-based data reporting; and a focus on content that typically comprises a smaller portion of the science curriculum standards in most states than other areas of science (Barstow & Geary, 2002;

Feldman, Konold, & Coulter, 1999; Songer, Lee, & Kam, 2002). Research on intermediaries in Earth science education, therefore, has the potential to inform how other programs address these challenges.

Hypotheses

In multiple-case study designs, it is important to explore *rival hypotheses* that explain the phenomenon being studied (Yin, 2003). Researchers need to gather and analyze evidence that supports both primary or alternative, or rival, propositions as explanations for patterns in the data. By gathering data on rival hypotheses, researchers can reduce the risk that only their initial theories get serious consideration while alternatives are overlooked during case study analysis.

Our hypotheses and their rivals are drawn from the literature cited above and from our earlier studies of GLOBE partners. These hypotheses are used to guide the case study analyses that follow. We list and elaborate on each below:

Hypothesis 1: Mentoring. Face-to-face mentoring from a GLOBE partner helps teachers to overcome common obstacles to implementation.

Rival: Lower-cost alternatives to face-to-face mentoring can be equally effective in helping teachers overcome obstacles to GLOBE implementation.

Evaluation studies of GLOBE have identified several barriers that make the Program challenging for teachers to implement, including problems with obtaining equipment, limited Internet access, and difficulty with identifying appropriate data collection sites (Means et al., 1999; Means, Coleman, & Lewis, 1998; Means et al., 2000; Means et al., 2001). At the same time, our research indicates that face-to-face mentoring is an important predictor for different levels of data reporting (Penuel & Means, 2004). For purposes of this study, we began with a definition of mentoring as providing direct, one-on-one assistance to teachers on an as-needed basis. One GLOBE partner has suggested that face-to-face visits are the most important component of the mentoring process, because they provide an opportunity for teachers to solve problems of implementation jointly with an expert in the Program. Such mentoring is costly, and just over one-third of partners surveyed reported that they are able to provide it. It would be advantageous if lower-cost alternatives could be identified to support mentoring.

Hypothesis 2: Supporting Student Research. Built-in GLOBE supports for student research are sufficient to encourage student research in classrooms around the world.

Rival: Specific work by intermediaries is necessary to support the implementation of student research in classrooms.

In order to meet the educational goals of the GLOBE Program, it is important not just for students to enter local data for use by scientists but also for students to take part in a process of scientific discovery related to those data. Student research can help students make connections among what they are learning in class, the research of actual Earth scientists, and their own observations and experience in the world. The GLOBE Program has a number of built-in supports for student research: for example, there are suggested research activities in the GLOBE Teacher's Guide, and data from local sites worldwide is available for comparative analysis on a Web site. However, research indicates that teachers need additional supports beyond standard curriculum materials to implement student-driven investigations in their own classrooms; they need opportunities to practice new teaching strategies in the context of their pre-service and in-service preparation (Carpenter et al., 2004; National Research Council, 2000), access to experienced support providers (Carpenter et al., 2004), and professional development that is part of a coherent science education reform strategy (Garet, Porter, Desimone, Birman, & Yoon, 2001) and is sustained over time to support the ongoing development of an "investigative classroom culture" (Supovitz & Turner, 2000). The GLOBE Program office is insufficiently staffed to provide such supports to a broad range of teachers; however, GLOBE partners may be well positioned to offer some of these supports to teachers as a supplement to the supports and incentives within the GLOBE Program.

Hypothesis 3: Curriculum Integration. The work of partners with teachers to align GLOBE activities with standards and assessments helps teachers identify multiple opportunities for integrating GLOBE into their curriculum.

Rival: Teachers' perceived conflicts between teaching to standards and implementing GLOBE often prevent them from implementing the Program, despite the alignment efforts of partners.

Standards, large-scale achievement tests, and accountability systems are important drivers of educational reform throughout the United States and increasingly in other countries as well. Earth science typically does not occupy a central place in the standards or tests of most states, however (Barstow & Geary, 2002). In evaluation surveys and interviews, GLOBE teachers have reported that standards and accountability pressures often prevent them from implementing GLOBE (Means et al., 2000). To address these concerns, many partners work actively to help teachers align GLOBE with their state's standards. It is not known whether these strategies are effective, or if the perceived conflicts are major obstacles to GLOBE implementation even in regions where partners have spent time aligning GLOBE with local standards and assessments.

Hypothesis 4: Sustainable Funding. A few strategic relationships with other programs and with policy-makers allow partners to build a sustainable funding base.

Rival: A broad portfolio of strategic relationships helps transcend the unpredictability of single relationships in establishing a sustainable funding base over time.

GLOBE's partners get their funding from multiple sources, but different partners have developed different strategies for accomplishing the goal of a sustainable, stable funding base. Two strategies that are common but not widely understood include: (1) to seek a few strategic relationships of central importance or (2) to seek a broad portfolio of strategic relationships to reduce the risk associated with any individual relationship. We investigate these here, in an attempt to learn more about which strategy might be more effective.

Selection of Cases

In a multiple case study design, it is important to select cases that are either similar or that contain hypotheses predicting contrasting results (Yin, 2003). For this study, we selected two GLOBE Program partners: GLOBE in Alabama and the partnership run by the University of Alaska Fairbanks. The two cases are similar in that they both provide supports to teachers after training and support student research with GLOBE as one of their primary goals. They are also similar in their level of success to train teachers who implement GLOBE: these partners have the highest percentages of GLOBE-trained teachers who report data among U.S. partners.

The selected partnerships differ with respect to the geographical regions and student populations they support, as well as the specific support structures they have chosen to provide. In addition, we selected teachers to interview for this study who differed with respect to the types of support they received from their GLOBE partners, in order to test our hypotheses about the importance of mentoring and other forms of post-training support for student research and standards alignment. We also sought teachers with different GLOBE implementation patterns to test our hypotheses about support and curriculum integration.

Protocols and Procedures

SRI researchers prepared interview protocols for each of several important categories of participants in partnerships and the schools they serve. A partner leader interview (Appendix A) focused on the structure of the partnership, funding strategies, and central challenges. A partner staff member interview was used with mentors, affiliates, and other people who assist with professional development or other teacher support functions. A school administrator interview focused on principals' perceptions of the Program and its fit within their school. A teacher interview aimed at finding out how teachers were implementing the Program, their obstacles to implementation, and how (if at all) they overcame those obstacles.

Where possible, we also conducted structured observations (Appendix B) of GLOBE activities in classrooms and in the field. These observations were designed to capture instructional goals, materials used, and sequences of activity. We attempted to capture dialogue and discourse throughout the observations in selected classrooms. Each of the observations lasted from 45 to 60 minutes.

The site visits took place in spring and summer 2003, and researchers spent a week in each state. Case study researchers visited each partnership in pairs and set up visits to schools ahead of time. Where possible, researchers were asked to set up site visits in different regions of the states and to include both a rural and an urban school in their sample. Before their visits, case study researchers were given instructions on how to use each of the protocols and data capture forms and were trained in their use in a session that included practice interviews in a role-play format.

Data Analysis

Upon return from case study sites, each research team completed two data capture forms. First, they completed a rubric for each school they visited, providing evidence in support of the rival hypotheses from interviews, observations, and artifacts they collected. The rubric was based on a model of GLOBE implementation developed for the evaluation of the Program (Penuel, 2003). Rubric elements included not only implementation depth and quality but also the quality of external supports to teachers, including those provided by the GLOBE partner. Second, case study teams created a summary of five key themes from their case studies, providing evidence backing each theme. These themes were then reviewed by the partner leaders as a check on their validity and to offer opportunity for comment.

Both these documents were used to organize the study findings with respect to the key hypotheses. We systematically reviewed evidence from interviews, the rubrics, and the thematic summaries to produce the case study reports that appear in the sections below. The case study analyses were conducted as if the case studies were replications of one another: we reviewed one case, and then we conducted our analysis of the second case in light of the findings of the first. An advantage of treating the cases as replications is that we can review evidence in light of a revised (and potentially more refined) set of hypotheses about the role partners play in supporting implementation. However, schedules and other practical constraints precluded conducting these case studies as true replications, which would have necessitated the revision of site visit instruments after the first case to gather systematic data on the revised hypotheses.

In this chapter, we use the names of partnerships and their leaders, not pseudonyms. We do so because they have been collaborators with us in the study. We view their participation as critical in helping to establish the validity of our findings and have found that they are open to discussing their challenges as well as their successes. Nevertheless, researchers independently developed the hypotheses and conducted the primary analysis on which this paper is based. As a further point of independent reference we look at partnership effectiveness from the viewpoint of teachers. All teacher and school names are pseudonyms.

GLOBE in Alabama

GLOBE in Alabama, led by Director Greg Cox, has long been a significant and visible partner within the Program. A primary component of its strategy in the recent past has been a system of mentors throughout the state who provide one-to-one support to teachers implementing GLOBE. Until recently, these mentors were led by another key staff member in the organization, Jennifer Lockett, who served as the original mentor and helped to organize mentoring activities throughout the state. GLOBE in Alabama has trained hundreds of teachers, many of whom have implemented GLOBE. The partner was able to obtain grants for equipment and funding for the kinds of follow-up support that have been associated with higher data reporting, and Alabama GLOBE teachers have reaped the benefits. This success is a key reason behind selecting this partner for the case study.

Another significant achievement of this partnership has been its integration with other statewide initiatives. The organization participated in the Alabama governor's blue ribbon panel to reform mathematics, science, and technology education, and Greg Cox has served as a leader with the Alabama Math, Science, and Technology Initiative (AMSTI) that grew out of the blue ribbon panel's efforts. The mentoring model employed by GLOBE in Alabama is the model for preparing teachers in AMSTI. Furthermore, the partner's visibility within the GLOBE Program as a whole also makes it an important, credible intermediary organization both within the state and beyond.

In the following section, we explore teachers' experiences working with this partner, reviewing evidence related to our central hypotheses under each subsection. At the conclusion of the section, we consider revisions to our hypotheses that reflect what we learned in Alabama before turning to the Alaska case study.

Teachers' Introductions to GLOBE

The first necessary step in taking a program like GLOBE to scale is teacher recruitment. In Alabama, this step was supported strongly by the widespread connections of the GLOBE partner with other organizations related to Earth science and Earth science education. For example, GLOBE middle school teacher Fran Kastings is a member of a local hiking club and takes her students each spring to Oak Mountain State Park, a 10,000-acre park whose northern edge touches the school property; she heard of GLOBE through a ranger there who was working with a GLOBE mentor. Fifth-grade teacher Mary Castella first encountered GLOBE activities at her local arboretum and was attracted to the Program "because the world is global," and local issues are global issues. In general, the GLOBE teachers in Alabama with whom we spoke encountered GLOBE through networks of people they already knew who shared their concern with the environment. These networks may be important supports to GLOBE's scaling in Alabama because they are trusted sources of information for teachers and thereby more effectively promote interest in the GLOBE Program.

Mentoring

Widespread implementation of GLOBE in Alabama has also been supported by Alabama's GLOBE mentors, who work to ensure that a high percentage of teachers trained will implement the Program. The Alabama staff includes four paid, part-time mentors who are available to help trained GLOBE teachers through school visits, e-mails, and phone support. Each mentor is assigned to assist the schools in one or more geographic regions. They respond to teacher requests and make periodic visits to schools whose teachers they have helped train, aided by greater local proximity than is offered by the more centralized bases of GLOBE in Alabama.

The mentors in Alabama all have multiple affiliations—GLOBE is just one. Two of the mentors work as education staff in local science museums, and another works for the state. A fourth is currently a full-time teacher. Their home-base organizations support their participation to varying degrees and for varying amounts of time. Not surprisingly, the mentor who also has teaching responsibilities has the least amount of time available to visit schools.

Mentors engage in various activities that they consider to be critical support for teachers implementing GLOBE. First, mentors provide models of GLOBE teaching methods during visits to classrooms: the mentors model learning activities, protocols, and effective questioning strategies by demonstrating them while classroom teachers are in the room, either as observers or as assistants. Second, mentors collaborate on curriculum planning to help teachers see connections between GLOBE and local curriculum or state standards. Third, mentors help teachers set up equipment and solve problems related to taking measurements at study sites.

In each of the schools visited, teachers had received face-to-face visits from mentors. Fran, the teacher described above, received a variety of supports from GLOBE in Alabama: mentoring (she can ask Taylor Steele to come on a weekly basis); refresher training; support for any equipment needs; and links to other GLOBE teachers (she works with an area high school teacher). According to Fran, these supports have been indispensable to her implementation of the Program: on-site mentoring has allowed her to observe GLOBE teaching, helped her solve equipment problems, and given her another "team teacher" to work with—a support that is not otherwise available in her current school.

These mentoring activities appear to have had a significant influence on teachers' ability to overcome obstacles to implementing GLOBE. The GLOBE Program includes a vast array of data collection protocols and activities, and both Fran and Mary characterized their initial training as "overwhelming," despite the fact that it was spread over 5 months. Both teachers report that mentors were instrumental in helping them take their first steps to implementation. Mary was initially discouraged because other teachers in her school who had been trained were not implementing the Program, and because she realized that she would have to wait an entire school year to purchase her instrument shelter (an important physical component of GLOBE) with school funds. She learned from GLOBE mentor Kathryn Royall that the partnership could provide the equipment at no cost to her school. Kathryn went to Mary's school and helped her set up the shelter and brought a GPS unit so that Mary could collect data about the study site.

In Cindy Kinnard's case, she had gotten started with GLOBE on her own but got help from a mentor to reimplement GLOBE after a 4-year hiatus. Cindy had suspended GLOBE implementation after changing schools, but learned from a colleague that GLOBE mentor Taylor Steele was offering refresher training courses. Cindy took the training with Taylor, and is once again using GLOBE with her students. She saw Taylor as someone who could help her get GLOBE started again in her new school. "He helps you remember how to do things," she said.

According to Greg Cox, there are distinctive qualities that make a good mentor, which we observed mentors exhibiting. First, mentors should have some teaching experience, particularly in inquiry teaching, whether in a traditional school or as part of an informal organization like a museum. Such experience helps to build trust with teachers and establish a pedagogical model that is consistent with using GLOBE to support student investigations and research. Second, the mentors need to be able to listen well to teachers and have the patience to manage a wide variety of situations. Careful listening is required to understand the serious obstacles to implementation that exist in schools and help teachers find solutions that are workable in their local settings. Finally, a strong science content background helps because GLOBE is content-rich but provides little scaffolding in its materials for teachers (or mentors) to be able to master concepts that may be foreign to them.

It would be a mistake, however, to attribute teacher success in overcoming obstacles to implementation to mentors alone. Fran, for example, had to wait for computer lab access before she could implement GLOBE; this was an issue that an outside mentor could not resolve. In addition, she teaches at a Christian school with a strong religious emphasis, and she was better positioned than an outside mentor to build a bridge between GLOBE and her school's Christian philosophy, presenting the Program in a way that would be viewed as consistent with the faith of the school community. In some cases this required adaptations of the Program; for example, Fran reports that some scientists' letters were omitted from the GLOBE Teacher's Guide for local use because of their inconsistency with school beliefs. Her principal's trust in Fran was a key factor in his decision to support GLOBE; he noted in our interview that Fran was critical in the school's effort to write its own science materials and added that she would be a key participant in an upcoming school science summit.

Student Research

The GLOBE Program can be implemented in a variety of ways in a given classroom. The minimum implementation that satisfies GLOBE headquarters is data reporting to the central GLOBE database that provides worldwide data for scientific study. A deeper implementation, and often a more meaningful one for educational purposes, includes student research and analysis related to the data collection they do in GLOBE.

Although GLOBE-trained teachers in Alabama have a relatively high rate of data reporting, the classrooms we observed provide little evidence of student research based on GLOBE data. One teacher reported that she would like to conduct a student research project but has yet to do so.

Another said that she introduced her students to information about the local Alabama soil, but her students do not appear to understand why soils are important to study: one student wondered aloud when she came across a Web-based soil survey why anyone would do “such a boring thing.” A third teacher has focused more on data collection and data entry than on data analysis in her classroom, and her students are neither familiar with patterns in their own data nor aware of what GLOBE scientists do with the data they report. Finally, while a third-grade teacher has been involved in a number of inquiry-based science initiatives and has her students begin all units by listing a set of testable scientific questions about the topic to be covered, these are unconnected to GLOBE activities.

Although students in each class we observed appeared engaged and motivated, for reasons that ranged from comparing their own measurement activities to those of other classes to intrinsic interest in the measurement technologies, student research was not a successful focus of the partner activities. We also found little evidence that resources provided by GLOBE to support student research were used widely in Alabama. We did not see students looking at patterns in their data in classrooms we visited, and students did not report looking at their data with any regularity. A large incentive for research that the program office offered during the years of our study was GLOBE’s Learning Expedition in Croatia. Students could submit reports to present there that posed original research questions that used GLOBE data they had collected in the analysis. Despite Alabama’s many reporting schools, no students from Alabama were selected to present in Croatia.

Greg Cox confirmed that GLOBE in Alabama has placed less emphasis on student research, and he noted that his partnership’s focus on encouraging data reporting is in response to an emphasis of GLOBE itself. Because he believes broader implementation will lead to higher-quality data for scientists to use, the partnership’s efforts have been focused on encouraging implementation and data reporting rather than on promoting student research.

Mentor Support for Curriculum Planning and Integration

One of the mentor roles identified as critical in Alabama is the support of teachers’ planning for integrating GLOBE into their curriculum. Fran cited the opportunity to walk through her curriculum with her mentor, identifying areas of curriculum fit with GLOBE, as one of the important initial supports that gave her confidence to implement the Program. Mary noted that assistance from a mentor was particularly important in addressing her concern that there would not be enough time in her curriculum to integrate GLOBE, helping her to see the points of alignment between the required Alabama Course of Study and GLOBE. Despite integration support from the mentor, Mary still found that available time for GLOBE was limited in her self-contained elementary classroom, which demands coverage of all subjects during the day. Her solution was to make GLOBE into a centers activity, exposing only some students to deep involvement in GLOBE activities.

The perception that GLOBE would not align with local curricula was not a problem for Cindy. Her school district was in the process of a 5-year reform of science education that emphasized student inquiry, and GLOBE content easily aligned with reform goals. Furthermore, although state accountability tests at the elementary level do not typically focus on science, parent advocacy at her school had resulted in a schoolwide emphasis on science. A room was dedicated to science at each grade level, and a large lab was built for all grades to use. Cindy perceived GLOBE to be a perfect fit that met both her district's reform goals and her parents' demand for science education. As a result, she was able to perform all the needed alignment without support from her mentor in this area.

Sustainable Funding

A key to the success of the Alabama GLOBE partnership has been its ability to establish the funding and infrastructure to support mentors, equipment, and other activities, in part by creating a place for GLOBE within the state's mathematics and science initiatives. Their funding strategy has been to seek financial support from a combination of private and government sources. The mentor program has been funded by two state sources: the Department of Community Affairs, which gave the program approximately $125,000, and the State Department of Education, which contributed another $145,000. These contributions were significant for establishing GLOBE in Alabama, but they do not ensure its sustainability, as the flow of state resources to GLOBE can be affected significantly by a change in administration. As government funding is invariably unpredictable, and there has been little continuity of funding over the years, Greg Cox is looking to raise additional funding from the private sector to fully fund GLOBE in Alabama.

The sustainability of partnership programs like mentoring is further supported by GLOBE's successful alignment with Alabama math and science initiatives. The GLOBE Program is seen as a valuable component of math and science teaching in the state; as a result, GLOBE training is now integrated with several other science initiatives, which helps to sustain training programs and broaden GLOBE's reach to more teachers and mentors.

Revisiting Hypotheses about GLOBE Partners

Before turning to an analysis of GLOBE and the University of Alaska Fairbanks partner, we consider how our hypotheses about the role of partnerships in supporting implementation might be revised or refined to better reflect findings from the Alabama case study. The revised set of hypotheses will serve as a guide to our analysis of the Alaska partnership.

Hypothesis 1: Mentoring

Given that all the teachers we interviewed in Alabama had received face-to-face mentoring and all cited this assistance as essential to implementation, the Alabama case does not offer any evidence to contradict the hypothesis that this form of mentoring is necessary to overcome obstacles to implementation. For each of these teachers, evidence supports the claim that face-to-face interaction with mentors helped them implement the Program in their classrooms. It must be acknowledged, however, that even with support from mentors, teachers continue to play a central role in overcoming obstacles to implementation.

The Alabama case study further revealed that mentors, through their own participation in social networks of science educators, are critical agents in the Program's scaling process. Two of the three teachers in our study had encountered GLOBE through the people who became their mentors. Like partner leaders, these mentors are important in bringing new teachers to GLOBE. GLOBE in Alabama may be unusual in being able to rely on intermediaries of its own; whether this strategy might work as a recruiting tool in other partnerships merits further investigation.

Hypothesis 2: Student Research

In Alabama, we did not find examples of students engaging in research using GLOBE data. We may have missed such examples because we focused more on elementary schools, where student research is less likely, but in previous visits to Alabama middle and high schools we found little evidence of student research in those settings either (Means et al., 2000). The examples mentors put forth for inquiry were instead good examples of hands-on activities that engaged students' curiosity. In the one classroom we visited where students posed their own questions to guide inquiry in the classroom, these were not connected to GLOBE activities.

From our case studies in Alabama, therefore, we found little evidence to support either the idea that GLOBE's own incentives and supports were adequate for encouraging student research or the idea that mentors' activities encouraged it. Only one of the teachers we interviewed, Cindy, had clear ideas about how to foster student-directed research in the classroom, and in her case, the school district and parents were the primary drivers. The district provided professional development to support the adoption of inquiry teaching in science, but promoting student research in GLOBE was not part of that effort. To support teachers in promoting student research may take a much more concerted effort that involves coordination among GLOBE partner staff, district staff, and teachers.

Hypothesis 3: Curriculum Integration

GLOBE teachers in Alabama listed curriculum integration among the critical supports they received from their mentors. One of the key activities in which mentors engaged was to help teachers map GLOBE to the Alabama State Course of Study. They did not just provide teachers with a list of standards; instead, they worked side by side with teachers to identify opportunities to integrate GLOBE into their curriculum in ways that helped them meet state standards. In that respect, both mentors and teachers felt the work that mentors did to help teachers see alignment with standards was critical to supporting implementation.

At the same time, neither partners nor mentors are completely able to overcome the difficulties teachers face in integrating GLOBE with their curriculum. In some cases, teachers had to map to parochial school standards and educational values with which the mentor was unfamiliar. In other cases, teachers needed to see the connections between GLOBE and their state's curriculum frameworks and standards for themselves. Where teachers perceived particular protocols to be both difficult to implement and only partially aligned to standards, they chose not to implement the protocols. As one teacher said of the Soils protocol, a favorite of her mentor: "It's a great idea, but I wasn't going to do it" because it didn't fit with her school's curriculum.

Hypothesis 4: Sustainable Funding

GLOBE in Alabama has proven continuously resourceful with respect to funding, pursuing both small and large funders. Overall, the Program has focused on a few strategic relationships with state officials and major partners, such as NASA. This focus has paid off in terms of helping to ensure GLOBE's place in Alabama's major mathematics and science initiatives. Yet neither state nor federal grant funds have proven to be consistent or reliable over time; funding has fluctuated greatly from year to year. More data, over a longer period of time, are needed to understand what kinds of strategies may successfully produce a sustainable funding base for Alabama over the long term.

GLOBE in Alaska

The GLOBE Program at the University of Alaska Fairbanks (UAF) is headed by soil microbiologist Elena Sparrow, who is also a GLOBE scientist in the area of Phenology. The Alaska GLOBE partnership started with funding from a handful of small grants and has grown to its current position as one of the most active and visible of the GLOBE partnerships. A distinguishing feature of the partnership is its successful blend of educational, scientific, and cultural concerns in its teacher training activities combined with its strong support of GLOBE in local communities. The Program has engaged scientists, teachers, and Alaska Native elders to explore how GLOBE can become one lens, along with other scientific and cultural ways of knowing, for observing changes in the local environment.

Like GLOBE in Alabama, GLOBE in Alaska (through the UAF GLOBE partnership) has developed partnerships with other science and education programs as well as statewide initiatives, which have in turn helped the GLOBE Program to scale. One such initiative is a statewide attempt to integrate Native Alaskan cultural knowledge with science education, which has provided an opportunity to align GLOBE more effectively with standards for reaching Native communities. Another important Program component in Alaska is the summer teacher institute, a 2-week workshop that weaves together the three strands of science, best teaching practices, and culturally-relevant curricula. Our site visit included an observation of the teacher institute, as well as a visit to a summer elementary program in a remote village that utilized GLOBE. We also interviewed several other teachers either in person or by phone.

In this section of the paper, we explore the Alaska partnership's primary strategies and how they have been experienced by teachers and students. We review evidence related to each of our hypotheses and finally consider how the hypotheses should be adjusted to reflect new insights gained in Alaska.

Student Research

The majority of GLOBE teacher preparation in Alaska is conducted within the Observing Locally, Connecting Globally (OLCG) program at the UAF, funded by an NSF grant since 2000. The goal of the OLCG program is to provide Alaskan teachers and students the opportunity to engage in original global change research and to promote education on global change, while presenting students with culturally relevant opportunities to learn. The project's 2-week summer training institute includes the participation of Native elders and other local Earth science experts to examine local Earth science issues and culturally responsive teaching and curricula as applied to GLOBE protocols and learning activities. By integrating the science and cultural content, leading education professionals provide instruction on the inquiry cycle and other best practices in science and math education, including strategies for supporting students in developing and carrying out scientific investigations. For example, when teacher participants in the institute conduct GLOBE investigations in teams and then present their results, the facilitated debrief of each presentation may focus on related pedagogical strategies, embedding both educational research findings and practical tips on such issues as facilitating teamwork among diverse groups of students.

The integration of GLOBE training with OLCG means that new teachers in Alaska's GLOBE Program have more varied opportunities to learn about inquiry science teaching than do most GLOBE teachers. Most standard GLOBE training focuses on mastery of the protocols, devoting less time to classroom implementation planning or to student research, and many partners report that their GLOBE teachers are not familiar with inquiry science teaching (Penuel et al., 2004). The added attention to inquiry and student research within the OLCG summer institutes offers a more comprehensive introduction to best practices in science education than is available to most GLOBE teachers.

In addition, GLOBE/OLCG staff report that they try hard to teach strategies that make GLOBE research relevant, capitalizing on students' innate questioning and curiosity rather than "assigning curiosity." This approach, they maintain, is well suited to the extremes of the Alaskan environment: in a natural setting where daylight and temperature vary drastically by season and climate change is immediately visible in the changing patterns of ice breakup or the height of tundra plants, questions about the environment come naturally to students and can easily connect to possible topics of research.

Another mechanism the Alaska GLOBE team has used to expand its focus on student research has been to establish collaborative partnerships with other inquiry-based science education programs. GLOBE protocols are positioned as the data collection arm for existing inquiry science programs such as the Schoolyard Long-Term Ecological Research Project, a program in which teachers and students conduct research near their school. These programs often provide models of professional development for teachers, frequently in the context of ready-to-use curricula or project ideas that help make the connection between GLOBE and local issues more visible and meaningful to students. As a result, GLOBE students in Alaska seem to have more opportunities to encounter inquiry with GLOBE than do students in other regions.

This increased statewide emphasis is reflected in Alaska's representation at the recent GLOBE Learning Expedition (GLE) in Croatia, a worldwide conference whose U.S. participants were selected competitively based on the quality of GLOBE student research reports they submit. Two students, each with their own project in the Fairbanks area, were selected to participate. One winning project was designed by a high school student, who chose to focus on the effects of hot water discharge from a local power plant on the dissolved oxygen levels of the nearby Chena River. She used GLOBE data to investigate the hypothesis that levels might be unusually low near the plant and therefore unable to support life. Her report incorporates a number of conventions of scientific communication: citation of prior work that frames the study, a clear explanation of the problem and its significance, a description of procedures she followed, and a statistical significance test to compare dissolved oxygen levels at two different sites along the river. Students from other schools have competed successfully at the Alaska Statewide High School Science Symposium and have presented at other international conferences.

For younger students, the research goals we observed were more modest. In a summer school class with students in the first through fifth grades, very little formal data analysis was conducted, but teachers did regularly engage the whole class in discussions of what their data might mean to help them better understand the science behind the measurements they were making. In this Native village, teachers drew upon local perspectives to add to the relevance of the activities; for example, the water cycle was introduced with a book called *Go Home River* about a trip taken by a Native Alaskan boy and his father to experience the river from its origin to the sea.

Mentoring and Posttraining Support

Observations and interviews with teachers in Alaska are consistent with findings in Alabama that led us to conclude that mentors and teachers each make a significant contribution to overcoming obstacles to implementation. GLOBE in Alaska attributes the high statewide implementation rate to a strategy of closely following teachers after training and providing them with needed support. According to partner staff, GLOBE in Alaska judges the success of the partnership not on how many teachers are trained but on the level and quality of implementation at the schools. High quality implementation is considered to be contingent upon regular follow-up with teachers.

A key vehicle for maintaining face-to-face contact with teachers is through annual GLOBE/OLCG conferences held in Alaska. At these conferences, teachers receive follow-up training in both GLOBE protocols and teaching strategies. They also have opportunities to share practices with other GLOBE teachers. According to one teacher, these conferences yield "wonderful insights" into how to organize instruction with GLOBE. Another teacher noted that the return trips to GLOBE help keep teachers up-to-date on the Program.

Despite the vast distances that separate many schools from the partner headquarters in Fairbanks, Elena and her staff work hard to make site visits and provide hands-on support for teachers. Where possible, face-to-face support is offered for each of the Program's three strands: (1) science (for example, troubleshooting GLOBE data collection challenges); (2) best practices and pedagogy (for example, OLCG co-Principal Investigator (PI) and GLOBE trainer Leslie Gordon helped make protocols age-relevant by teaching an elementary school class a lesson on percentages in preparation for a cloud protocol that expected students to estimate the percentage of the sky covered by clouds); and (3) culturally responsive curriculum (for example, OLGC co-PI and GLOBE trainer Sidney Stephens often helps to identify local Native elders and facilitates their participation in the classroom). According to one teacher, this active support is "invaluable… [and] the crucial thing that makes this Program work."

In addition, e-mail and telephone support on each of the three strands are extensive. Although the vast differences between villages in Alaska preclude the level of face-to-face contact during the school year that can be provided in Alabama, one remote teacher we interviewed told us that partner staff are "there for us if we ask for support." Another teacher said that partner staff have been essential immediate resources to call, and that she has "huge stacks of e-mail" from them with practical ideas and suggestions. This teacher found this specific local advice particularly important in an extreme environmental setting with many practical challenges to hands-on research, such as, "solar noon" for data collection after the end of the school day and permafrost preventing many types of data collection during most of the school year. The partner staff work hard to be responsive to teachers who ask for help; however, they suggested that many teachers do not avail themselves of the opportunity, and distance makes it more difficult to stay visible as a source of support.

Finally, the Alaska partnership promotes implementation after training by providing incentives and accountability for implementing the Program. Once trained, teachers are asked to submit journals of their teaching as well as student work samples to the partnership during the school year. These provide partner staff with insight into the level and quality of implementation and encourage teachers to follow through on plans developed at the annual Alaska GLOBE conference. Teachers are motivated to complete the work because they receive course credit at the UAF, which is contingent on them either reporting data or demonstrating through journals and student work samples that they have conducted GLOBE-related learning activities. As an additional incentive, many teachers receive grant funding to subsidize tuition expenses at UAF and pay for travel to the summer training institute and the annual conferences.

Alignment with Standards

As in Alabama, the Alaska partnership has worked actively to demonstrate alignment with state science standards. Elena Sparrow, Leslie Gordon, and one of the GLOBE teachers with whom we spoke serve on a committee to revise the standards, and they are discussed in the context of GLOBE training. Also as in Alabama, teachers play a very important role in helping to make connections to standards that allow them to implement GLOBE. One teacher described a collaborative curriculum integration process among the science team at his school; another described the way she must defend the use of GLOBE to school leadership. A third teacher serves on the state science standards committee, and uses resulting understanding of the alignment process to help her make connections between GLOBE and standards.

In addition to alignment with state science standards, the Alaska GLOBE partnership has sought to align the Program with a set of standards that specifically address the needs of Native Alaskan students. The state developed these additional standards, called the *Alaska Standards for Culturally Responsive Schools* (Assembly of Alaska Native Elders, 1998), to inform the design of instruction for the state's many Native students. These standards call on educators to identify ways that Native ways of knowing intersect with the forms of knowledge valued in school and in scientific disciplines, as represented by the science standards. They also promote ways of involving Native communities as active participants in education.

Culturally-responsive curriculum design is one of three core strands of instruction in the summer teacher institute. The institute includes explicit discussion of culturally relevant instructional models as a guide to curriculum development. It also integrates contributions from a number of Native participants who talk about traditional knowledge and observations of climate change: for example, elders leading a boat trip talked about respect for the land and changes over time, and a Native teacher from the northern whaling village of Barrow described a Native-scientist partnership that informed international policy on whaling restrictions.

Working locally with elders and other members of the local community is also promoted through ongoing facilitation by partner staff, who help make contacts and coach teachers in respectful relations and in creating opportunities for community participation in the classroom. Teachers consistently cited the ongoing challenges of involving elders—elders are far less visible and accessible in cities than in villages, for example, and their conceptions of time and topic may depart from the common workings of the classroom. The mentoring they receive from the Program on these topics, according to teachers, is invaluable.

GLOBE teachers have reported that elder involvement can help to overcome resistance from school leaders to implementation. Sandy Hamilton, who also teaches in a school that is comprised primarily of Native students, says she gets little support for GLOBE from her principal and colleagues. She notes that the leaders in her school are all "scared of science" and that there is extreme pressure to increase scores on the state standardized tests. But she is inspired to implement GLOBE because of the involvement of elders that the Program has facilitated. Elders visit her class and talk about topics like climate change that include reference both to the ways that Native elders observe change and the way changes can be observed by GLOBE students. Sandy observes,

> GLOBE is culturally relevant for students: the elders talk about the old sweat lodges and their predictions for great changes in the climate. Now this makes sense to the kids. It is easy to make GLOBE culturally relevant for them: there's a lot of flexibility and ability to expound on what they already value in their culture.

The experiences of teachers in Alaska we have documented in our case studies indicate that there are actors other than teachers and partner staff who can play an important role in supporting implementation. Community members can inspire teachers and students, particularly by helping to demonstrate the relevance of GLOBE to local issues and to ways of living that are valued within the cultural traditions of students, and these partnerships can help rebuild trust of the educational institution in Native areas that have long felt a disconnect with white-run schools. Partner staff agree that so far too few successful examples exist of the desired integration of Native communities into the life of the science classroom. Nevertheless, early signs demonstrate that this approach can help bridge science standards, the scientific approach to data collection represented by GLOBE, and environmental awareness that is sanctioned by the community.

Strategy for Sustainability

Elena Sparrow has a successful track record of pursuing grants to fund work with GLOBE and to build capacity for the Alaska partnership. Her grant strategy has been to begin by applying for small grants of just $5,000 to $10,000, and then gradually seek larger sources of funding. She has also built capacity by partnering with a network of trainers, scientists, and other science programs. These partnerships contribute to Elena's salary and fund trainers, as well as providing important in-kind benefits in the form of access to large groups of teachers and integration with existing curricula and classroom projects. Altogether, at least 14 major partners and grant programs support the work of the Alaska GLOBE, including both national and local sources.

Elena's approach is to view GLOBE as a way of supporting other science and education initiatives, which in turn support the dissemination of GLOBE. For example, GLOBE protocols are used to monitor coastal change in the Improving Understanding of Climate Change Variability program. Additionally, schools participating in the Schoolyard Long-Term Ecological Research Project are encouraged to use GLOBE protocols as a means to monitor changes in their local environment, components in the Earth system. By partnering with programs like these, GLOBE has become valuable to local scientists and educators alike by providing tools to address immediate needs faced by other Earth science programs. As a result of these partnerships, GLOBE is well integrated with a number of major state initiatives in Earth science education.

Discussion: Further Refinements to Hypotheses about GLOBE Partners

The Alaska partner's experience as reported here indicates that further refinements to our working hypotheses are needed to more accurately reflect the experiences of students, teachers, and partner staff in GLOBE. In each of the central areas of focus—important supports for student research, partner support, standards alignment, and funding—we found evidence that effective partnerships function in ways not anticipated at the outset of our study.

Hypothesis 1: Mentoring

Alaska provides a different kind of face-to-face encounter with partners than does Alabama, and the partner has developed effective strategies that do not rely on regular encounters with teachers throughout the school year. In addition to telephone and e-mail support, an important venue for mentoring is the annual Alaska GLOBE conference, which provides teachers with opportunities for sharing, for refresher training in protocols, and for implementation suggestions tailored to the local environment. Moreover, providing course credit for participation in GLOBE professional development activities appears to be a successful strategy for promoting implementation at a distance. Although teachers do not meet in person during the school year, they provide documentation to the partnership of their GLOBE activities, and credit is dependent not just on attendance at training but on successful program implementation. Teachers described their level of contact with the partnership as high despite limited face-to-face mentoring, providing support for the idea that these kinds of incentives may be a low-cost alternative to visiting schools regularly, especially in geographically dispersed regions like Alaska.

Hypothesis 2: Student Research

In contrast to Alabama, the Alaska partnership specifically promotes student research in GLOBE through its professional development offerings. It also provides accountability and incentives to teachers for implementing GLOBE, a strategy that is relatively uncommon in the Program. Together, these supports appear to pay off in terms of concrete student research projects.

At the same time, the coordination of Alaska's own incentives and the GLOBE office's competition for students to go to Croatia may have worked together to promote some projects. Alaska sent multiple student groups to the GLE and other international conferences, more than any other single partnership in the United States. Their experience suggests that GLOBE's own models and rubrics *can* be a guide partners can use, but it is important for the partners to share those as part of their professional development and provide follow-up to support student research with GLOBE as it gets under way.

Hypothesis 3: Curriculum Integration

As in Alabama, we found evidence that both partners' and teachers' work to align GLOBE with standards and assessments was critical. But we also discovered that Native elders played a significant role in supporting curriculum integration. Many schools in Alaska are "minority-majority" schools; that is, their student bodies are comprised of students who are more than 80% Native Alaskan. These students' cultural backgrounds are a rich source of knowledge about the environment, and GLOBE through OLGC has consciously sought to make their cultural traditions part of the Program. This inclusion has proven successful in overcoming obstacles to implementation, and it has also helped to weave GLOBE more closely into the fabric of community life in small villages.

Hypothesis 4: Sustainable Funding

Although not all individual sources of funding have been stable, the Alaska partnership's approach of creating a broad portfolio of strategic relationships has helped transcend the unpredictability of single relationships and funding sources to establish a sustainable funding base over time. Each of the organization's partners provides either a source of funding or direct support for broader implementation. Moreover, through Elena's dual role as soil microbiologist and educator the organization has sought both science and education partnerships, securing a more diverse portfolio of supports for the mission of GLOBE.

Implications of Case Studies for Partners and the GLOBE Program

A hallmark of both case study partners was the diverse strategies they used to mentor teachers, with similar positive effects on implementation. The case study research outlines a range of successful forms that mentoring can take. Face-to-face support, especially mentoring, may be too expensive for all partnerships to undertake. Still, it has proven effective in both these partnerships. When distance prevents school-year visits, an annual conference—such as the one sponsored by Alaska—may be a good way to get teachers together. When cost prevents regular contact, partnerships providing incentives similar to those given to Alaska's students can be effective. Providing credit through distance learning courses to teachers promotes participation, and when incentives are tied to data reporting or implementation, teachers appear more likely to follow through than they would be if credit were tied solely to attendance at the training. Although these posttraining activities serve as incentives for promoting implementation, they do not support implementation directly in the same way that mentoring does. Mentoring provides a window into a teacher's classroom and her context and often provides information about how a teacher may be adapting GLOBE (creatively or unproductively) to her local context.

Partners were not the only important agents in supporting implementation in either state. In Alabama, teachers themselves played a critical role in gaining principal support for their participation in the Program and in forging connections between their work in GLOBE and other local initiatives in science. In Alaska, teachers in some cases called in Native elders to support their work and to help them justify to their school leaders why GLOBE could be an important educational experience for village youth. Certainly both GLOBE-created and partner-generated materials may have supported these teachers, but the work they did on their own was critical to overcoming barriers to implementation.

The contrast between the two partners' approaches to promoting student research also resulted in different levels of student research with GLOBE. In Alabama, where mentors promoted the idea of inquiry as hands-on activities designed to spark student curiosity and where we saw few students who looked at patterns in their schools' data, there was little evidence of sustained student research. By contrast, in Alaska where student research was promoted through formal professional development, students sought out and won several successful entries for spots in the GLE, other international conferences, and statewide science symposiums. It may be that the clearer definition of student research, coupled with the incentives and resources provided by the partner and by GLOBE during the year of our study, worked together to promote student research in GLOBE. If that is the case, it is likely that in other partnerships a similar approach may be needed to make the vision of student research that uses GLOBE data a reality.

These findings have some implications for GLOBE's new strategy of emphasizing the creation of "GLOBE Learning Communities" (GLCs). GLCs are a new idea in GLOBE, encouraging partnerships to include more community-based organizations and members of the community in helping support GLOBE. Both Alabama and Alaska have found creative ways to include community members in GLOBE, although they have not found it easy to do so. Especially interesting is Alaska's inclusion of Native elders in GLOBE. Although we did not begin our case studies with a focus on community involvement, the fact that these elders emerged as significant supports to implementation merits further attention in the Program and in our research.

It appears that resources on standards-alignment provided by GLOBE Headquarters and posted on the Program's Web site had little influence on teachers' thinking, but partners did help teachers see that the alignment between GLOBE and their states' standards. The joint activity of "crosswalking" among teachers' existing curriculum, state standards, and GLOBE activities was particularly helpful in facilitating implementation, according to mentors and teachers in both Alabama and Alaska. It is not known whether such crosswalks, if simply handed to teachers, would have been as effective as the joint work that the partners engaged teachers in to construct these in the context of planning for GLOBE implementation. Future research might investigate this possibility, since it may be either the joint work of mentors and teachers that is the critical factor or the local relevance that is important to making it easier for teachers to implement GLOBE.

With respect to funding, it is clear that there is no magic solution to the problem of creating a sustainable base of funding. However, both partnerships have been strategic in forging partnerships with multiple organizations and with state organizations. As a result, they have been successful in finding a level of funding that has—through good times and bad—been able to keep the partnership moving forward. Both these partners' strategy of seeking funding from science and education sources has been critical to their success. Partners should certainly be encouraged to find leaders who are familiar with both these possible sources of funding.

Alabama and Alaska Partners as Intermediaries in Earth Science Education

Both the Alabama and Alaska partners functioned as intermediaries do in systemic and schoolwide reforms that have been studied elsewhere. Like comprehensive school reform models where intermediary organizations have been helpful in the past, the partners focused on helping teachers reach a challenging goal: implementing a program that requires intensive and regular field study that only partially maps onto teaching practices with which teachers are already familiar. The partners, like other intermediaries, provided the necessary support to help teachers solve problems associated with the enactment of inquiry science activities in their curriculum (with differing degrees of success). By helping solve problems and providing models of teaching, they helped to lower barriers to the adoption of inquiry teaching approaches in science.

As intermediary organizations, both partners played an important part in helping to *localize* an international curriculum supplement. By localization, we mean the process of making connections between the broad goals of the curriculum and the local goals of educators and helping teachers adapt the program activities to fit within the constraints and demands on teachers. Such localization was a critical focus of the Alabama and Alaska partnerships' activities; and although teachers often adapted curricula on their own to meet local circumstances and in some cases without much help from others, our study indicates that partners as reform intermediaries can help teachers by making explicit through conversation the opportunities for curricular integration, the kinds of student encounters with curriculum materials that may be more productive, and the ways activities may have to be adapted to fit a particular school schedule or set of grade-level content standards.

Localization has another meaning specific to Earth science education as a field. Of particular import to engaging students in inquiry in Earth science education is helping students and teachers identify questions to investigate that have particular relevance to the local environment. In Alaska, for example, the unique conditions of permafrost permit students to ask questions that cannot be posed or investigated directly by students in Alabama. The more temperate climate in Alabama enables students to go outside to collect temperature and precipitation data throughout the year and address a different set of student questions about weather and climate. Intermediaries can help teachers and students identify Earth science questions of local significance that are feasible to investigate as part of a classroom or after-school activity.

As intermediary organizations, moreover, these partners may have played a role in improving the quality of teachers' adaptations of inquiry curriculum. An enduring concern of science inquiry curriculum developers has been the degree to which teachers' adaptations of their curricula result in "lethal mutations" of the Program's design (Brown & Campione, 1996; Brown & Edelson, 1998; Cohen, 1988; Reiser et al., 2000). In our case studies, we saw evidence of different kinds of scaffolds to improve the quality of teachers' implementation of curriculum, including structuring incentives and formats for reporting on implementation and providing models of how to facilitate student inquiry. Although we do not have evidence from the present study that implementation was comparatively more effective in the classrooms where intermediaries provided support, we do know from earlier research that there is greater overall fidelity of implementation when teachers are mentored by intermediary organizations (Penuel & Means, 2004).

Despite the critical roles that these intermediaries appear to play in GLOBE, both organizations we studied faced considerable and ongoing obstacles to sustainability. They are not atypical of GLOBE partners in this regard, and their dependence on a patchwork of small and short-term grants limits their ability to work on an ongoing basis with the teachers they serve for multiple years. It has been widely recognized, however, that the school reform process is a long and slow one. Reform intermediaries like the partners we studied need more stable sources of funding and tighter integration among diverse curriculum initiatives if intermediaries are to achieve the kinds of "revolutionary" changes in Earth science education that have been called for by reformers.

Materials Study

Introduction

Supplementary curriculum materials such as those that form the core of the GLOBE Teacher's Guide demand much of teachers. Studies suggest that teachers need curriculum materials from which they themselves can learn, in order to use the materials well (Borko & Putnam, 1996; Wallace & Louden, 1998). In response, reformers and researchers in science and mathematics education have called for the development of *educative materials* for teachers, that is, materials that support teachers in learning what they need to know to enact curricula successfully in their classrooms (Ball & Cohen, 1996). Among the kinds of educative materials that have been developed for science are materials to help teachers improve their understanding of content, to diversify their pedagogical strategies, and to enhance their pedagogical content knowledge (Schneider, Krajcik, Marx, & Soloway, 2002).

As the GLOBE Teacher's Guide has been revised over the years, more educative material directed to teachers has been included. For example, the gray boxes provide teachers with an overview of investigation areas and their learning objectives. In addition, content learning is scaffolded by introductory text written by scientists about the significant Earth science and Earth systems ideas. Earth as a system has its own area for curriculum integration, given that teachers need to communicate the understanding of Earth as a system of systems, a fundamental idea in Earth science. Yet information is scant about how teachers use the educative aspects of the GLOBE materials, how they think with and about the materials, or how they adapt the materials to their own classroom contexts.

The purpose of this study is to gain a thorough understanding of how teachers use GLOBE materials. Specifically, we are interested in (1) the content and pedagogical knowledge supports teachers use from the materials, as well as what the teachers bring to the materials, (2) the extent to which teachers are able to infer and use the significance of the protocols for the advancement of Earth science, (3) teachers' practices of curriculum integration with GLOBE, and (4) teachers' adaptations of the material to the specific grade level and learning styles of their students.

This chapter summarizes the study design and the key findings. We explain our methodology and sample and organize our findings according to the four core research questions. On the basis of interviews with GLOBE teachers, we provide a list of suggestions for the GLOBE Program. This materials study was completed using the Teacher's Guide that was current prior to the 2003 version. Some of the findings have been addressed in the 2003 version.

Study Design

Methodology

To ensure a thorough review of GLOBE materials, we conducted semistructured in-person interviews with teachers. We used, among other techniques, verbal think-aloud protocols to elicit teachers' thinking about how they interpret GLOBE materials that are relatively unfamiliar to them (Ericcson & Simon, 1993; Schneider & Krajcik, 2002). Our goal was to interview from six to eight teachers of various grade levels during the 2002–03 school year. We chose to focus our study specifically on Atmosphere and Hydrology materials since previous evaluations of GLOBE found them to be the most widely implemented investigation areas. During the interviews, several of the teachers also mentioned their use of other investigation areas, particularly the Soil investigation area.

To ensure that participants were sufficiently familiar with the GLOBE materials to provide feedback, we first conducted a search on the GLOBE Web site for schools in northern California that had made at least 20 data entries for either Atmosphere or Hydrology in the previous 2 years. We then used a telephone screening protocol (Appendix C) to determine whether the teachers we were contacting were using the Atmosphere or Hydrology materials or both of these. Once we determined their suitability for the interview, we requested their participation in our study and offered them a $30 gift certificate from the Web site Amazon.com as an incentive for them to meet with us.

Before the interview, teachers were sent an online survey that was created by using the Web site Zoomerang.com (Appendix D). This survey served two purposes: (1) to help the researchers prepare for the interview by providing information on the specific protocols and activities the teachers had or were using, and (2) to better understand the context in which the teachers were working without adding additional questions to the in-person, hour interview.

Interviews were then conducted at the teachers' schools either during their preparation periods or after school. An SRI researcher and a student associate conducted three of the seven interviews, including both of the pilots; the remaining four interviews were conducted by the student associate alone. A semi-structured protocol was developed to address teachers' general use of the materials as well as their implementation of specific protocols and activities within the Atmosphere or Hydrology investigation areas (Appendix E). Interviews ranged from 45 to 90 minutes. All interviews were recorded and transcribed. Data from individual interviews were then organized according to the main interview questions and synthesized across sites according to the four core research questions.

Sample

We conducted two pilot interviews. Because no significant changes were made to the interview protocol, we included the data from the two teachers with the data from five subsequent interviews. Six of seven teachers were from schools in northern California that were within 2 hours driving distance from the SRI office in Menlo Park. One teacher was from a high school in Queens, New York; this interview was conducted while the student associate was visiting the area. The sample included two third-grade self-contained teachers, one fourth- and fifth-grade self-contained teacher, another fifth-grade teacher, one sixth-grade math and science teacher, and two high school science teachers. Three teachers were female and four were male. All of them were veteran teachers with at least 7 years of teaching experience. They had all been implementing GLOBE for more than 2 years at the time of the interview, and one of the teachers had been trained to be a GLOBE trainer.

We included several general questions in the online survey to understand the school and classroom context in which the teachers were working. Six of the seven teachers reported that their students were either at or above grade level. Several of the teachers had either state-adopted textbooks or Full Option Science System (FOSS) kits, but all of them said that their science curriculum was somewhat flexible and allowed them some degree of freedom to incorporate GLOBE. Three of the teachers said that their school's curricula already met the expectations of the state, and as a result, they faced no increase in pressure to teach to the standards. The remaining four teachers reported either a very high or high emphasis on standards at their schools. All of the teachers stated that their schools placed some level of emphasis on hands-on and inquiry science; several teachers mentioned that the school board supports GLOBE and that they received funding from the parents association for GLOBE equipment. At five of the schools, the teachers we interviewed were the only ones trained and implementing GLOBE at their schools; at one of the high schools and one of the elementary schools, other teachers had been trained in GLOBE, but only the teachers we interviewed were implementing the Program.

Overall Findings

Teachers indicated on the online survey which of the protocols and activities they had implemented (Figures 4-1, 4-2). During the interview, teachers were then asked to elaborate on their use of one or two of these protocols and activities. The Cloud and Temperature protocols and the two Cloud learning activities were the ones most of the teachers chose to focus on. This was especially true among the elementary school teachers. The two high school teachers focused on their use of the Hydrology and Soil protocols.

Figure 4-1. Protocols Teachers Have Implemented

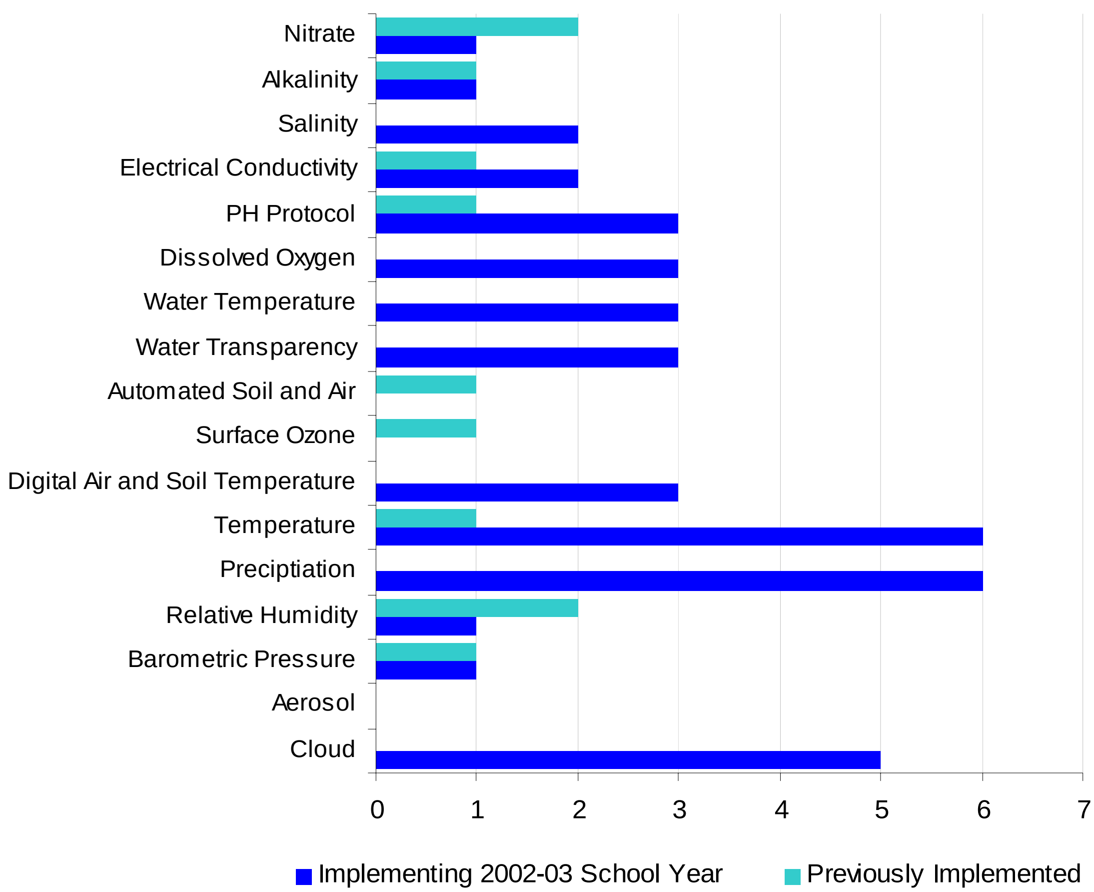
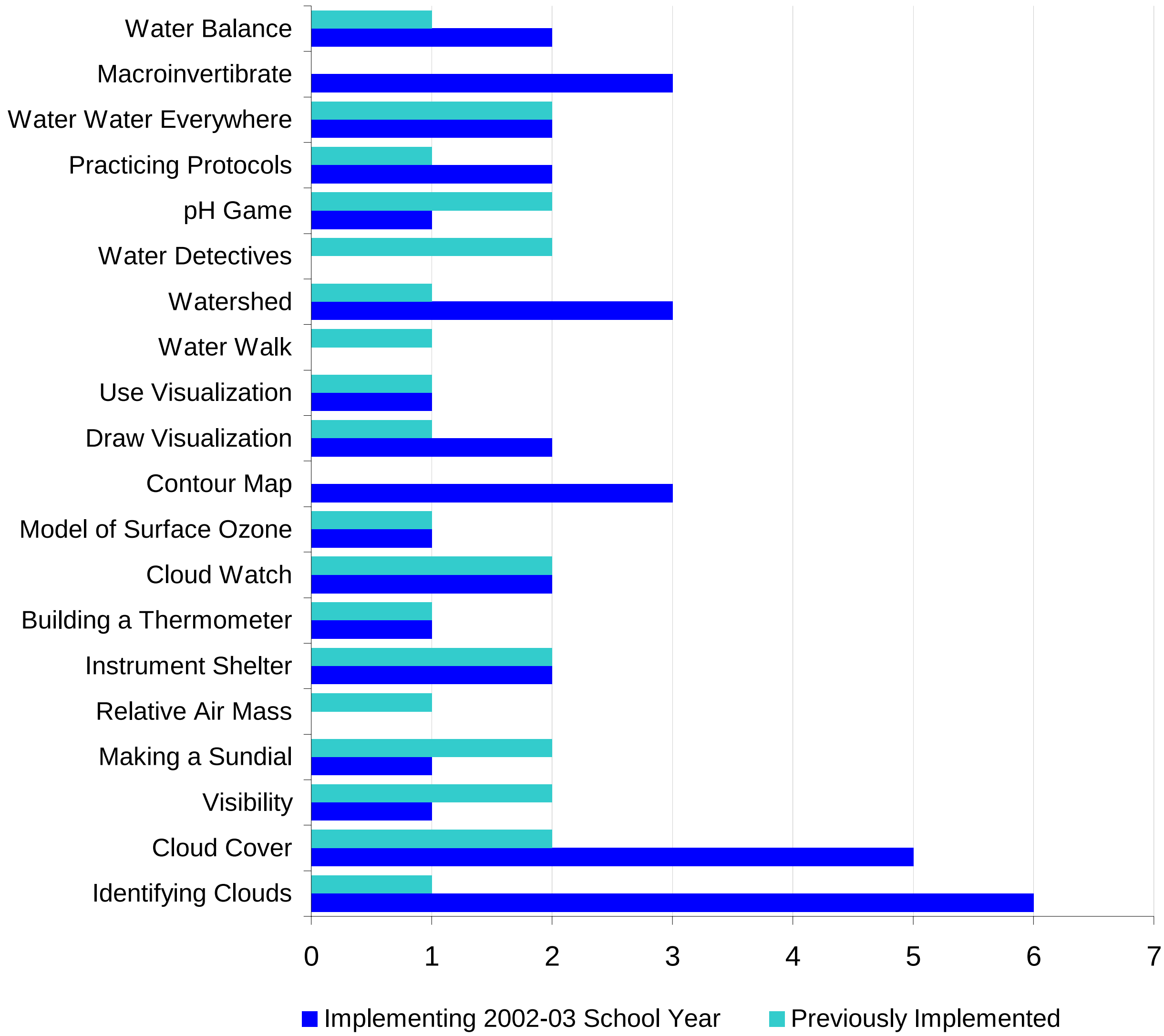


Figure 4-2. Activities Teachers Have Implemented



Overall, all seven teachers spoke very favorably about the GLOBE Program and their use of its materials. They appreciated the flexibility of the curriculum and the fact that it goes into depth without pressuring teachers to enact every protocol and activity. However, because they viewed GLOBE primarily as a hands-on science curriculum, teachers found it difficult to focus responses in interviews on the materials without talking about how they use them. Although teachers used several educative materials in the Guide, including background information, directions, field guides, and diagrams, they did not rely on these materials to teach their lessons. Rather, the teachers used the materials to help students learn to use the equipment and instruments and do science. While this approach created some difficulty in conducting interviews, it does suggest that GLOBE is reaching its goal of offering hands-on, experiential science to teachers and students.

Core Research Questions

1. What content knowledge and pedagogical content knowledge supports do GLOBE teachers use from GLOBE materials when implementing GLOBE?

When asked what they rely on to implement GLOBE, the teachers' most common response was that they learned how to implement the protocols and activities through their training sessions. The protocols, even the ones that seemed very complicated, became much easier once GLOBE trainers showed teachers how to implement them. As one teacher said,

> Actually going through the Guide and doing different activities such as identifying the clouds helped. If you just give a teacher a list of protocols and don't have them actually do it, then they're not going to do it. It would just end up on a shelf, collecting dust. You really need the training in order to actually have the teacher do it.

Back in their classrooms, all of the teachers use the hard copy of the Teacher's Guide and, to a lesser extent, the online version to help them implement GLOBE. They read the background material and refer to the gray boxes to refresh their memories so that they can choose which protocols and activities to implement. They also use the gray boxes to prepare their materials, estimate how long the lessons will take, and write their lesson plans. Teachers who have been implementing GLOBE for several years said that they no longer use the lesson overviews as often, but they think they are invaluable for a teacher new to GLOBE. Often teachers add some key questions or adapt the lesson to the grade level of their students, but for the most part the teachers reported that the GLOBE materials are straightforward, thorough, and easy to implement. One teacher said, "I think any teacher, even a beginning teacher can just pop the page out of the curriculum and use it as it is. The lessons play out how they are written. The order and the flow really work. The curriculum developers thought about it in terms of one thing leading to another."

Teachers find the Teacher's Guide contains a lot of information that is useful both for their own learning and to answer questions posed by their students. Table 4-1 shows which sections of the Guide are most used by the teachers we interviewed. Although none of the teachers said that they have used the matrix that correlates GLOBE with national science standards, several teachers predicted that they might use it more now that policy-makers are more focused on standards-based reform and testing. One high school teacher said he does not rely on the gray boxes but rather goes through the manual to see what catches his eye and looks interesting for his students. He said, "I just thumbed through and I looked at the illustrations, like a kid looking at a picture book picking out what I liked." When asked what made the activities appealing, the teachers responded that they are hands-on and help make science a little less dry and a bit more exciting.

Table 4-1. Use of Sections in the Teacher's Guide

	Have Not Seen	Have Seen But Not Used	Have Used
Step-by-step directions	0	0	7
Gray boxes	0	1	6
Introduction/big picture	0	1	6
Matrix of science standards	1	6	0

In addition to the Teacher's Guide, six of the teachers also rely on additional material they received from their trainers that were not produced by GLOBE. For example, they received worksheets and charts on universal time, sheets explaining the cloud names, and activity sheets requiring students to take pH readings of different liquids. One of the teachers also received maps showing surface temperature from an educational services consulting company called the LOOP Center. Four of the teachers also rely on material they and other teachers created. When asked how often they use the GLOBE Help Desk online, six teachers said rarely and one teacher reported that he has never used it. One teacher also mentioned that he used to monitor the GLOBE Mail but stopped because it involved mostly contests and online chats that he believed are not appropriate for his class. Two teachers said that they use the student investigations page on the GLOBE Web site. They look at the different projects and then point their students to the ones that are feasible in terms of time and the level of difficulty. One third-grade teacher found the projects on the Student Investigations page to be appropriate for children older than those in her class and therefore does not use it.

Teachers differed in the way they introduce GLOBE to their students. Some teachers provide background information first; others start by doing a protocol or learning activity and then explaining the concept behind it. One high school teacher said that reading the welcome and introductory sections provided good background information but that he was confused about how to use it. He said he used the learning activities because their use in the classroom made more sense to him. For many of the lessons, he recommended teachers start with the learning activities because "kids just want to do." The activities get the students involved right away and warm them up to the protocols, which are more advanced and rigorous.

The elementary school teachers tend to read the background material for their own understanding and then verbally summarize the information that they think will be interesting to their students. They give the students the technical terms but explain them in ways that are easier for the students to understand. Several of the teachers also rely on their science class textbooks for background information because they believe that the textbooks cover what the students are supposed to know and are written at an appropriate reading level. Both of the high school teachers photocopy a lot of the GLOBE materials for their students to read themselves. For the Soil investigation area, both high school teachers read through each page and use the curriculum almost verbatim. Although he has textbooks on soil science, one teacher hands out pages from GLOBE because they are better and more concise. Two teachers, one at the elementary level and one high school teacher, also make PowerPoint presentations to present the information.

These differences in the way teachers introduce GLOBE to their students suggest that there may be advantages to one approach or another depending on how a teacher intends to use GLOBE. It may be that teachers who wish to use GLOBE as a way to involve students in inquiry in science should start with an activity. Teachers who wish to emphasize measurement and data reporting skills might begin with an emphasis on the role of GLOBE as a data source for scientific investigations around the world. A greater understanding of the merits of different approaches to introducing GLOBE could be a future area of study.

Looking specifically at the Atmosphere investigation area, teachers said that the Getting Started section is straightforward and helps them prepare their lessons. They also said that the section on measurements is useful, especially the information and chart on calculating solar noon. While negative comments were not made about the written instructions and diagrams on instrument construction, the teachers bought most of their instruments and thus did not need to construct them. The teachers said that the diagrams and instructions on the site selection and set-up guides make sense and are easy to guide their students through. Two teachers said that they follow the directions on calibration exactly to ensure they are measuring accurately; by using GLOBE materials they are able to teach the students how to calibrate and why it is necessary to do so. For the Cloud protocol, two teachers said that the cloud chart on the field guide was very useful for the students to refer to. For the Temperature protocol, two teachers mentioned that the picture of the maximum/minimum thermometer helped the students use and understand Celsius. Several teachers copied these materials for the students to take into the field; others put them on overheads. The elementary school teachers commented that the graphs in the Looking at Data sections have too much data for their students to understand. Both third-grade teachers mentioned that their students had trouble understanding the metric system before use of GLOBE materials.

For the Hydrology investigation area, several of the teachers do not have access to water but still use the material to teach the theoretical concepts. For instance, one of the high school teachers uses GLOBE to teach water quality, the hydrologic cycle, and water transparency even though his students are unable to take measurements. He appreciates the brevity of the introductions and likes that they "got to the meat and then moved on."

Even though this materials study did not focus on the Soil investigation area, both of the high school teachers have school farms and use these protocols extensively. They find the materials include everything about soils that the students need to know in order to analyze their farms' soil. One of the high school teachers said that when he teaches a unit on soil ecology, he uses a few of the learning activities and then does the protocols on soil pH and soil temperature. They study the different microbes, the soil texture, and the soil structure. The students also track nitrates on the school farm, which helps them understand sustainable farming. Through GLOBE, he is able to explain why soil ecology is important in a farming ecosystem. The other high school teacher implements the Soil protocols with his Plant Cell Science class and with his Regional Occupational Program class. He said,

> I used to make my own material; even though I thought mine was pretty good, this is far superior to what I had. GLOBE has the most comprehensive protocols and learning activities for environmental science. I don't think there's a better piece of work, I just don't. This is really good stuff.

2. To what extent can and do teachers infer the significance of the protocols for science from GLOBE materials?

Teachers mentioned using the video, the Teacher's Guide, and the Web site to help them understand and explain to their students why GLOBE is useful to scientists. Several teachers introduce GLOBE to their students by showing the video so that the students learn the purpose of GLOBE and that other students around the world are participating in the Program. The video shows that GLOBE involves real-life scientific studies and real-life scientists who use the data. It shows the importance of weather stations. Teachers said that the video is a good hook; the students are excited and a discussion tends to follow as students ask a lot of questions about how the Program works.

Specific sections of the Teacher's Guide that help teachers infer the significance of the protocols include The Big Picture and Scientists' Letters to Students. The Guide also helps to explain why and how certain instruments are to be used. Teachers said that unlike textbooks, GLOBE materials make science real for the students. One high school teacher said that his favorite activity is the Macroinvertebrate Discovery because "the kids are in the water, they look at those creepy crawly things that are in there and identify them. There's so much stimulus in that lab because you can feel the water, the actual rocks, the soil and just being out in a different environment than the classroom." The other high school teacher said,

> With GLOBE, we read the little passage and look at the soil triangle and then go out to the farm. We put the soil in our hands. I tell them that I want them to get their papers dirty. I want them filthy. I want to see that they're down and dirty. This is what science is about. And it is nice to be able to do that directly rather than just give them questions in the back of the chapter in a textbook.

Even though the standards call for students to know what one teacher calls "specific factoids" that hands-on science may not address, this third-grade teacher said he is more concerned that his students understand the scientific method and learn how to solve problems. GLOBE provides students with challenging hands-on activities and experiments; they try new ideas, see, and record their data. He explains the importance of documenting their failures so that they do not keep making the same mistakes. He said that his students gain a better understanding of how things work than they would by learning facts and definitions on their own. He wants them to be involved, to have fun, and to develop a love for science. He said, "GLOBE gives the kids who are not as book-smart a chance to shine and to come up with some great ideas."

Although teachers say that their students are excited and invested in GLOBE as they begin collecting data, two teachers said that entering the data into the Data Archive is key to students understanding what they're doing. It reinforces that there is a purpose for taking measurements. The students feel more connected when they get e-mail messages from the Help Desk. They also enjoy seeing all of the different resources on GLOBE's Web site, such as pen pal mailing, and experiments and activities related to the lessons they are working on.

In addition to their use of the video, Teacher's Guide, and Web site, teachers said that the best way to convey the significance of GLOBE to students is by introducing it in an enthusiastic manner. Teachers, especially those teaching elementary school students, try to get their students excited about and impressed by GLOBE by making its scientific aspects clear to students. Students especially like looking at satellite imagery, as well as knowing that NASA is helping sponsor the Program. Teachers explain that the students are special because they are part of a GLOBE school. Teachers show students some of the data and pictures from other schools, and students get excited because they know that they are involved in something beyond their school. One teacher said, "I think they get more connected to the Earth through GLOBE. They see what science is about and that science is all around you all the time." The students like being in the field with a clipboard, recording the data, and entering it into the

Data Archive because they feel like they are scientists who can collect data and contribute to the scientific community. Students understand that scientists use their data, and that by taking measurements, students are contributing to scientific information around the world. Another teacher said,

> GLOBE helps me make a link for students to real-world science. So often the kids are used to just doing stuff here and they ask, "Why do we have to know it?" GLOBE really offers me an opportunity to show that there are real scientists that use the data and that they are participating in a large-scale experiment. It's not just an experiment that we're doing in our class, but it has global impact, which is kind of cool.

The sixth-grade teacher specifically mentioned the materials on remote sensing because they make it easy for her to explain the scientific concept of spectrums to her students. She shows the video on remote sensing every year because it has a good example of infrared, the near infrared, and other spectra of light. Even though she doesn't use all of the remote sensing protocols, her students get an overview of satellite imaging and do some of the activities to learn how satellites work. One of the high school teachers who teaches in a farming community said that GLOBE helps his students understand why their watershed is of the utmost importance to the quality of their ground water and soil. GLOBE has helped his students—many of whom did not have science in elementary and middle school—understand the scientific method and write like scientists. For the more advanced concepts, he has them develop a hypothesis, collect the data, and then write scientific papers.

One of the third-grade teachers said that his students know that the scientists are using their data, but they don't understand what the scientists are trying to find out. The students read a letter from one of the scientists that said scientists are studying the weather, but the students still did understand how their data would be used and analyzed by the scientists. One exception was the Phenology protocols; students seemed to understand that examining the time of budburst was related to temperature and could be a tool for investigating weather and climate. Otherwise, he and his students have only a general understanding of GLOBE data's significance to scientists.

3. How do teachers integrate the use of GLOBE materials with other activities into their curricula?

All of the teachers interviewed said they are confident that GLOBE addresses state and national science standards and they therefore can integrate the Program without having to refer to the standards matrix. Their confidence comes from years of teaching experience and from reviewing with their teaching teams the curriculum standards they are expected to meet in the subjects they teach. Most of the teachers introduce one or two protocols in September so that the students learn to take measurements and can continue doing so throughout the school year. This is especially true for the Cloud and Maximum/Minimum Temperature protocols. The elementary school teachers find climate is a good place to start because students are already somewhat familiar with looking up and observing weather conditions. Several of the elementary school teachers also use the Estimating Cloud Cover activity early in the year. Other protocols and activities are introduced during the year as they relate to topics in the regular science curriculum. Teachers said they make their selections on the basis of what they remember from their training sessions and by flipping through the Teacher's Guide or browsing online at the titles and brief descriptions of the lessons. When probed, several teachers said that they also refer to the gray boxes to determine whether the lesson is grade-level appropriate and feasible in terms of materials and classroom management. These teachers recommended that teachers new to GLOBE start with a few activities and one or two protocols rather than trying to do everything.

Some teachers introduce GLOBE as a separate science activity and have a separate bulletin board for GLOBE work. Other teachers do not introduce GLOBE per se; they just integrate the protocols and activities to enhance their regular science curriculum. The consensus, however, was that the easiest and most efficient way to integrate GLOBE is to use it to substitute or supplement activities that are already in the curriculum. Teachers often find that GLOBE labs are better and more challenging than what they have in their textbooks.

Several of the teachers require that their students keep science journals or data logs, but only a few of them said that they give tests or additional assignments specifically focused on learning in GLOBE. One of the high school teachers said that he gives written and performance-based tests and has his students make presentations related to GLOBE concepts. One of the third-grade teachers uses GLOBE online where there are different pictures of clouds, and the students can test themselves. Sometimes he incorporates this test into their science grade; sometimes the test is a class project in which the students work on the computer. One teacher has her students listen to the weather meteorologist on television and then create their own weather chart for a week. Another teacher asked her students to research a city in the country and imagine that they are meteorologists reporting the weather in that area.

Teachers use different grouping structures and classroom management techniques to implement GLOBE. Four of the teachers recommend working in small groups of no more than 10 students and enlisting the help of parents and aides to monitor the students. They said that some of the activities, such as Making a Sundial, can be done with a full class but that in order for GLOBE to be a hands-on activity rather than just a demonstration, data collection and data entry should be done with just a few students. Once a week, one of the third-grade teachers sets up science stations where small groups of students work on different activities. Each station is monitored by an adult, usually a parent or a classroom aide. The teacher types a summary of the lesson that includes the background information and gray box explained in layman's terms and gives a copy to each adult. The fifth-grade teacher trains one group of students who then teach the others so that each student gets a chance to go to the GLOBE Research Corner and use the Internet. Another teacher has her former students work with her current class. Two teachers mentioned using GLOBE during summer school, which works well because they are afforded more flexibility and smaller classes than during the school year.

Several teachers commented that students are excited to take the measurements at first but that it becomes tedious after a while. In addition, teachers found that sometimes logistics, such as conflicts in the schedule, kids not wanting to give up lunch or recess time, broken instruments, and bad weather, preclude them from taking accurate and consistent measurements. To keep the students motivated, teachers suggested implementing GLOBE in an after school club with several students who are really enthusiastic about it, using it as part of a reward system, making it a classroom job, corresponding and sharing data with other schools, or using GLOBE data for science fair projects.

The Atmopshere protocols related to taking weather measurements seem to be easy to integrate into any science curriculum, whereas some of the other Atmosphere and Hydrology protocols are easiest to integrate into an Earth science or environmental science curriculum. Teachers find that GLOBE meshes nicely with other projects they are involved with such as the JASON Project (http://www.jasonproject.org/) and the Trout in the Classroom Project (http://www.troutintheclassroom.com/). The teachers also have ideas on how to integrate GLOBE with language arts, math, social studies, and art. One teacher said, "After teaching for a while, you know, you have your bag of tricks." With language arts, one teacher said that GLOBE helps her students learn how to use a lot of adjectives in order to make detailed observations. Another teacher includes literature by reading *Cloudy With the Chance of Meatballs* and *Hot Air Henry* to her third-grade students. All of the elementary school teachers mentioned integrating GLOBE with their math curriculum. They said GLOBE helps students understand Celsius and the metric system, how to read a thermometer, how to make and interpret graphs, how to estimate percentages, and how to use formulas. The sixth-grade teacher has her students look at how a temperature graph mirrors the topography of an area. She said that looking at the two together helps them to understand how science, math, and geography skills and knowledge together help them understand a phenomenon. Teachers also integrate geography by using the global positioning system (GPS) and discussing the location of their school compared with the latitude and longitude of other GLOBE schools. When teaching the different cloud types, both third-grade teachers integrate art. One has her students paint the different types of clouds so that they can picture what the clouds look like. The other teacher prints artwork from Ansel Adams and some photographs and pictures from the San Francisco Art Gallery on the Internet and has his students identify and describe the clouds in the pictures.

4. Are GLOBE materials more easily used and adapted in some settings rather than others?

The elementary teachers were more likely to create their own materials than were the high school teachers, who found the reading level of GLOBE materials appropriate for their students. One high school teacher, however, said that while his advanced placement (AP) class can breeze through the material, he has to go over the vocabulary and content of the readings with his freshmen, two-thirds of whom read below grade level. All of the elementary school teachers said that they need to provide either verbal explanations or readings from the science textbooks because the reading level of the GLOBE materials is too advanced for most of their students. The primary teachers also said that they find it necessary to redo the lab guides, field guides, and data sheets because the ones provided by GLOBE are too complicated. The GLOBE materials have too much text, too small font, and not enough pictures for younger and non-English speaking students. The graphs in the Looking at Data section are also problematic for students at the elementary level. Several teachers prefer that their students create the graphs with their own data so that "they see the relationship between what they are putting in and what they are getting out." They found the GLOBE visualizations where there are three or four elements that overlap with little squares and little diamonds to be too busy and difficult for the students to understand.

In addition to creating their own worksheets, primary school teachers also add more hands-on activities to convey scientific concepts to their students. For example, when one teacher works on the pH protocol, he starts by testing for acids and bases and does a hands-on activity with purple cabbage. Seeing the color change, his students are able to understand what is meant by saying something is an acid or alkaline. Then he gives the students pH paper and introduces the meter that is used out in the field. The students test different things for their pH level so that by the time they go outside, they understand what they are testing.

The high school teachers, on the other hand, skip several protocols and activities on temperature and rainfall because they are too simple for their students. One teacher said that he hopes to adapt these lessons to high school level by having the students forecast the weather. The students would have to follow high and low pressures, temperature gradients, and isobars and study barometric pressure to make an accurate forecast. He also hopes to have his students learn how to read weather and topography maps. The same teacher finds that some of the other activities, even though they are written for elementary students, work well with some of his high school students who have never been introduced to some of the concepts. The lower level activities are easier for his students to comprehend, they are easier for him to plan, and the students seem to enjoy them more. He uses these easier activities to prepare his students for the more advanced Soil protocols.

The sixth-grade teacher feels that GLOBE materials provide enough activities, but her concern is lack of instruments. She therefore wants to design additional lessons that would enable her students to do the protocols as a whole class but that only one group at a time would use the instruments. She plans to rotate groups using the instruments, but in order to monitor work with the protocols, she needs to plan other activities to keep students busy while they are not using the equipment.

Besides creating additional materials, teachers use heterogeneous groupings and alter the pacing of the lessons for younger students and those who are non-English speaking. The fifth-grade teacher said she usually pairs her students in teams that are heterogeneous and academically diverse. She therefore has not had to adapt the curriculum because her students are able to help each other with the lessons. Other teachers find that by going slower, breaking the lessons down into easier steps, and constantly reinforcing the ideas, they are better able to convey the concepts. For example, to explain how Celsius ranges from 0 to 100, the sixth-grade teacher posts the classroom temperature in degrees Celsius. This gives her students a reference point and reinforces what degrees Celsius feels like.

Suggestions from GLOBE Teachers for Improving Materials

The two biggest struggles teachers face are not having enough time to implement as many of the protocols and learning activities as they would like and not having enough equipment and supplies. Although the teachers gave positive feedback about the Teacher's Guide, they did make several suggestions for improving the materials. In general, teachers would like more hands-on activities, especially at the elementary school level. Specific suggestions relating to the curriculum materials, the GLOBE Web site, training, and equipment are listed below.

Curriculum Materials

- It would be helpful to have GLOBE trainers compile a list of additional activities that could be either added to the activity section or included in a separate booklet.
- The standards matrix should be organized by grade level with protocols and activities specifically designed to be integrated with curricula at different grade levels.

- To help teachers integrate GLOBE with their language arts curriculum, it would be helpful to have a list of books that relate to the different protocols. This would be especially helpful at the elementary level.

- For teachers new to GLOBE, it would be helpful to have a mini guide. The GLOBE Teacher's Guide is extensive and would be less overwhelming if the background information could be synthesized.

- Lab guides, field guides, and data sheets should have larger font and more pictures and diagrams, especially for younger children. Also, more illustrations are needed to explain how to use the equipment.

- The graphics, particularly in the Hydrology investigation area, are very well done but should be bigger so that teachers could scan them and put them in PowerPoint presentations or on overheads.

- The graphs in the Looking at Data section should be made less difficult; they currently have too much data.

- More activities on groundwater would be helpful for the Hydrology investigation area. For instance, information on aquifers and the pollution of groundwater would be useful.

GLOBE Web Site

- It would be helpful for teachers to take digital pictures and e-mail them to GLOBE to ensure that they have accurately identified clouds.

- GLOBE should provide more opportunities for online collaboration between schools.

- There should be more interactive activities on the Web site that students could do independently either at school or at home. For example, there could be a virtual stream with fish and plants, and students could change the pH of the water to see how it affects the stream.

- Teachers would like to see online student journals like those in the JASON Project. The students would enjoy writing in the journals more than using pencil and paper and it would be more efficient for teachers.

- Also on the Web site, it would be helpful to have a page where teachers could share their ideas for teaching GLOBE and to get ideas for other activities and books.

- When downloading and printing from the Web site, the fonts do not look the same and are not always readable.

- Some teachers have had trouble with the Data Archive; their data was not accepted, and they were disconnected from the site. Thus, they said technical improvements may be needed so that use of the site is less cumbersome, especially for primary school students.

Training

- It would be helpful if the training sessions were scheduled for teachers of similar grade levels rather than having kindergarten and high school teachers learning together.

- Trainers should make it clear that some protocols do not have to be done in their entirety in order for teachers to be able to enter their data.

- Initial trainings are good for learning the protocols, but it would be helpful to have follow-up trainings where teachers could focus on how to apply and implement the protocols. The follow-up training should involve more hands-on activities and make-and-take sessions. Teachers could discuss the activities they have done with their students and any problems they are encountering. They could talk about how they present the materials to their students and what has worked well for different grade levels.

Equipment

- It would be helpful to have alternative equipment. For example, the dissolved oxygen kit is too advanced for elementary school, and it would be beneficial if there were something similar like tablets that dissolve. The students could then have a full understanding of what dissolved oxygen is by the time they reach middle school. Similarly, having a protocol or activity where younger students could use pH paper rather than the pH pen would be beneficial.

- Expiration dates are needed on the chemicals used in GLOBE activities.

Other

- Partnerships such as GLOBE and the JASON Project might be possible; their protocols are similar enough to provide metadata and offer more options for elementary school children.

Student Outcome Study

Introduction

Learning about water and the hydrosphere is an important part of content standards for middle school students. For example, the National Science Education Standards (NSES) emphasize that students in the fifth through eighth grades should understand that the hydrosphere is one of four interacting components of the Earth system (National Research Council, 1996). According to the NSES, students need to understand how water cycles through the Earth system (the water cycle), and that because water is a solvent, it dissolves minerals and gases and carries them to the ocean. The *Benchmarks for Science Literacy* emphasize that middle school students must understand that water is essential for life and that the water cycle plays an important role in shaping climate patterns (American Association for the Advancement of Science, 1993).

Learning about water quality and related hydrology concepts is a popular topic in the science curriculum today among students because it is relevant to students' lives (Brody, 1993). Studying hydrology is often engaging to students because it typically involves a combination of scientific inquiry, collaborative study, and community involvement. In inquiry-oriented lessons, students investigate water quality through observations and measurements, share results with others within and beyond their classroom, and make informed decisions about local and global environmental issues. The strong links to standards, alignment with student interests, and opportunity to develop inquiry skills together make the study of water and the hydrosphere a rich opportunity for teaching and learning in middle schools today.

Not surprisingly, therefore, a number of curricula and digital resources have been developed for water science studies to promote hydrology learning through hands-on activities. For example, Digital Water Education Library archives high-quality water-related curriculum materials and makes them available for K-12 educators and students (http://www.csmate.colostate.edu/dwel/). Similarly, Project WET (Water Education for Teachers) develops water-related curriculum materials and learning activities and provides training and workshops for K-12 teachers (http://www.projectwet.org/). The Program's Healthy Water, Healthy People unit engages upper elementary through high school students in water quality testing activities that sometimes involve data logging on handheld devices or computers (Etgen, 2002; PASCO, n.d.). Several other water quality data collection programs do the same (Baumgartner, 2004; Novak & Gleason, 2001; Rivet, Singer, Schneider, Krajcik, & Marx, 2000; Staudt, 2000).

Most of the studies on hydrology curricula are case studies focused on the description of design principles and the material development process. Some studies report preliminary findings on student learning and motivational benefits of hands-on data collection supported by technology (Novak & Gleason, 2001; Hsi, Collison, & Staudt, 2000). Other studies, such as those evaluating the use of data logging in a laboratory setting in science topics other than hydrology with experimental design have reported gains in student graphing skills, as well as their understanding of scientific experiments (Brasell, 1987; Friedler & McFarlane, 1997; Linn, Layman, & Nachmias, 1987; Svec, 1999). However, research to date has not experimentally tested the effect of hands-on data collection on student learning about hydrology.

In past GLOBE evaluations, we have not investigated the specific contribution that the Program's data collection activities can make to student understanding of hydrology concepts. We did find that high levels of data reporting in GLOBE are associated with higher levels of students' problem-solving skill and environmental awareness (Means et al., 1997, 2001); and the Program's data analysis activities contribute to higher scores on students' scientific inquiry skills and understanding of concepts in the Atmospheric investigation area (Penuel et al., 2003). However, the designs used in these studies limited the extent to which we could draw causal inferences from the results about the Program's effects on student learning. We knew that evaluation studies with more rigorous research design were needed to confirm the findings about these positive effects.

In Year 8 of its evaluation, SRI began a quasi-experimental study in a single school from a partnership in North Carolina to test the effects on student learning of GLOBE's data collection activities in the Hydrology investigation area. This chapter will describe our research questions that guided the study, the methods we employed, and the analyses of data conducted to evaluate our evaluation research questions.

Research Questions

The purpose of the study was to evaluate GLOBE's effects on student learning in the Hydrology investigation area and validate the findings from the previous evaluation studies by exploring the following research questions:

- Does GLOBE improve middle school students' understanding of hydrology concepts and inquiry skills?
- Does GLOBE improve middle school students' attitudes toward learning science in school and beyond?

Consequently, the study was designed to test the following hypotheses:

- H_1: Middle school students of a teacher who uses GLOBE in teaching the hydrology unit will gain significantly more from pre- to posttest on hydrology concepts and inquiry skills than students of a comparison teacher.
- H_2: Middle school students of a teacher who uses GLOBE in teaching the hydrology unit will gain significantly more from pre- to posttest on student attitudes toward learning science than students of a comparison teacher.

Study Design

Sample

A total of 123 students from 8 classrooms of eighth-graders participated in the study. Students in half of the participating classrooms (N = 60) were taught by the GLOBE teacher, and students in the other half (N = 63) were taught by the comparison teacher.

Methods

The study relied on a pre-post, comparison group design. The study compared student learning outcomes between classes taught with the standard school hydrology curriculum supplemented by the GLOBE protocols and learning activities and classes where hydrology was taught without the GLOBE supplement.

Students in each teachers' classes were similar in achievement. To ensure the equivalence of both conditions, we surveyed both the GLOBE teacher and the comparison teacher about the background of their students (e.g., ethnicity, achievement level) and about time spent on different instructional activities and core hydrology concepts. Both teachers taught the hydrology unit from their standardized curriculum for Earth science for 10 to 11 weeks from early August to early November 2003. The teachers reported that they regularly planned science lessons together and used mostly the same teaching materials, except for the GLOBE materials and a few other minor materials.

The instructional practices of the two teachers during the unit were also comparable. Both teachers focused mainly on the following three activities: learning science vocabulary, doing hands-on/laboratory activities, and filling out lab reports. Both teachers reported that they did these activities between one to three times a week. They also reported that they had students look at the same data displayed in different ways (for example, table and graph) about one to three times a month. Both GLOBE and non-GLOBE students reported in their surveys similar levels of use of non-GLOBE learning activities. Likewise, both teachers spent similar amounts of time on teaching hydrology concepts such as water quality/composition, water polarity, and pH. The only exception was water temperature: The GLOBE teacher spent one to two class periods on the concept, whereas the comparison teacher did not teach the concept at all. Additionally, the student survey data revealed that both GLOBE students and comparison students spent similar amounts of time (1 hour or less per week) on homework.

The main GLOBE activities the GLOBE teacher reported conducting were taking measurements according to GLOBE protocols and talking about the collected GLOBE data with students during the hydrology unit. The teacher reported implementing four out of nine GLOBE Hydrology protocols: Water Temperature, pH, Transparency, and Nitrate. She reported implementing the first two protocols two to three times during the unit; the latter two were implemented just once. After the data were collected, the teacher talked about the data with her students a few times during the unit. Additionally, she reported using two of the eight GLOBE Hydrology learning activities (Water Walk and Model Your Watershed). Both activities were used once during the unit. The GLOBE teacher and her students, however, neither reported the data to the GLOBE archive nor conducted further analyses or solved a question that the teacher chose. Students' survey data from GLOBE classrooms support the frequency of these GLOBE activities reported by the teacher (the correlation between the student reporting and teacher reporting of the frequency of the GLOBE activities was .80).

The background of teachers is relatively similar: both are novice teachers, having 1 to 1.5 years teaching experience in a school setting, with preservice training both in science and science education. However, the GLOBE teacher had more experience in teaching science in nonformal settings. She had taught in an environmental education setting for 3 years prior to becoming a middle school science teacher. In addition, the GLOBE teacher had earned master 's degrees in environmental management and teaching. The GLOBE teacher reported more inservice training, including 10-day GLOBE/GIS (geographic information system) training provided at the middle school in June 2002. In contrast, the non-GLOBE teacher had no training in GLOBE prior to this study.

Procedures

The pretests were administered in the second week of August 2003, a few days after the 2003–04 school year had started. The teachers administered posttests and the postunit surveys in mid-October or early November 2003. Table 5-1 shows how many students were in each classroom in the study who took the pretest and the posttest, as well as the postunit survey.

Table 5-1. Distribution of Study Participants by Classroom and Group

Classroom	Group	Number of Students with Both Pre- and Postassessments, and Postunit Survey
T1	GLOBE	17
T2	GLOBE	15
T3	GLOBE	12
T4	GLOBE	16
GLOBE Group Total		**60**
C1	Comparison	18
C2	Comparison	14
C3	Comparison	18
C4	Comparison	13
Comparison Group Total		**63**
Grand Total (GLOBE + Comparison)		**123**

Instruments

The study adapted two instruments for students and one instrument for teachers that had been developed by SRI for previous GLOBE evaluation studies: the student hydrology assessment (pretest and posttest) (Appendix F); the hydrology unit student survey (Appendix G), and the hydrology unit teacher survey (Appendix H). Some changes were made to the instruments to meet the needs of the study as well as to reflect findings from the earlier studies (Penuel et al., 2003).

Hydrology Assessment: The assessment of student understanding included 22 items: 14 items were open-ended (short-answer) items, 6 were multiple-choice, and 2 were a mix of the two (combined items). Some of these items tapped hydrology core concepts, such as how water quality is measured, how water quality affects aquatic life, familiarity with different features of water quality (e.g., dissolved oxygen, temperature, pH, transparency), and how topography affects water quality. Others were about inquiry skills related to hydrology investigations, such as study design, interpreting data, graphing data, instrument calibration, and communicating findings. At the time of scoring, two open-ended items were dropped (A7 and A10) because they were too difficult to score reliably.

Hydrology Unit Student and Teacher Surveys: Two versions were made for both the teacher survey and the student survey: one for the GLOBE teacher and her students and the other for the non-GLOBE teacher and her students. Both GLOBE and non-GLOBE versions of the teacher survey asked about student background (number of students, achievement level) and time spent on different instructional activities, as well as on hydrology core concepts, during the hydrology unit. The GLOBE version of the survey also asked about the implementation of GLOBE protocols and learning activities. Similarly, both GLOBE and non-GLOBE versions of the student survey asked about students' experiences in their science classes and their attitudes toward science.

Scoring of the Hydrology Assessment

The multiple-choice items and open-ended items of the hydrology assessment were scored separately. The multiple-choice items were scored in the SPSS program with a two-level scale (0 for incorrect and 3 for correct). This scoring range matched the range used for the open-ended items.

The open-ended items were scored by two coders in North Carolina familiar with GLOBE. The coders were trained to use a rubric with a four-point scale (0–3) for each open-ended item. Interrater reliability for the first 20% of the tests was above .80 for all the open-ended items. After the reliability was calculated and confirmed to be above the acceptable level, the coders scored the remaining tests independently, blind to student condition. The scores given by the coders were scanned into SRI's data processing system and then transferred to SPSS. SRI researchers conducted quality checks at different stages of data processing and cleaning.

Student Performance on the Hydrology Assessment

Constructing the Scale for Analysis

Before analyzing the data, we looked at the difficulty levels of the 20 items on the hydrology assessment. To get a sense of how difficult the multiple-choice and open-ended items were, we estimated how many students responded correctly to each item by calculating the mean score per item and then dividing by the total possible score (3) to convert into a mean percentage correct score (Table 5-2). Items that were too easy (the mean percentage correct score was higher than .80) on the pretest and items that were too hard (the mean percentage correct score was lower than .20) on the posttest needed to be eliminated. As a result of this analysis, we eliminated one item (Item B-5) because it was too difficult. Consequently, the analyses were made with 19 items of the assessment.

Table 5-2. Mean Percentage Correct Score for Each Item

Item #	Item Format	Pretest	Posttest
A1	Multiple-choice	0.38	0.40
A2	Multiple-choice	0.77	0.69
A3	Combined	0.48	0.63
A4	Open-ended	0.29	0.36
A5	Multiple-choice	0.34	0.36
A6	Open-ended	0.44	0.33
A8	Combined	0.47	0.55
A9	Multiple-choice	0.25	0.27
B1	Open-ended	0.47	0.56
B2	Open-ended	0.62	0.68
B3	Open-ended	0.47	0.46
B4	Multiple-choice	0.58	0.59
B5	Multiple-choice	0.17	0.09
B6	Open-ended	0.36	0.39
B7	Open-ended	0.35	0.34
B8	Open-ended	0.43	0.39
B8_2	Open-ended	0.48	0.46
B9	Open-ended	0.26	0.27
B10	Open-ended	0.29	0.31
B11	Open-ended	0.23	0.35

Note: Mean percentage correct score was calculated by dividing per-item mean score by the total possible score of 3.

Additionally, we ran factor analyses to see if our scales measured distinct hydrology learning constructs, such as content learning and inquiry process learning. Because these analyses showed mixed results, all items were interpreted as measuring the broader construct of hydrology learning. Therefore, our reporting of results will focus on the overall scores.

Student Outcomes on the Hydrology Test

The total mean scores on pretests were different between the GLOBE and non-GLOBE groups, and the difference was found significant by *t*-test, $t\,(121) = 2.34$, $p < .05$ (Figure 5-1). To test the difference in change in scores controlling for pretest scores, we used an analysis of covariance (ANCOVA) test (

Table 5-3). The results of ANCOVA showed that, controlling for pretest differences in scores, there still was a significant difference in the score changes between the two groups. Gains by GLOBE students were, on average, greater than those of comparison students. The results also show that the pretest score was significantly related to change in scores, indicating that the understanding of hydrology concepts and inquiry skills prior to the hydrology unit had a significant effect on the overall score changes after the unit was taught.

Figure 5-1. Mean Gains on Total Score by Group

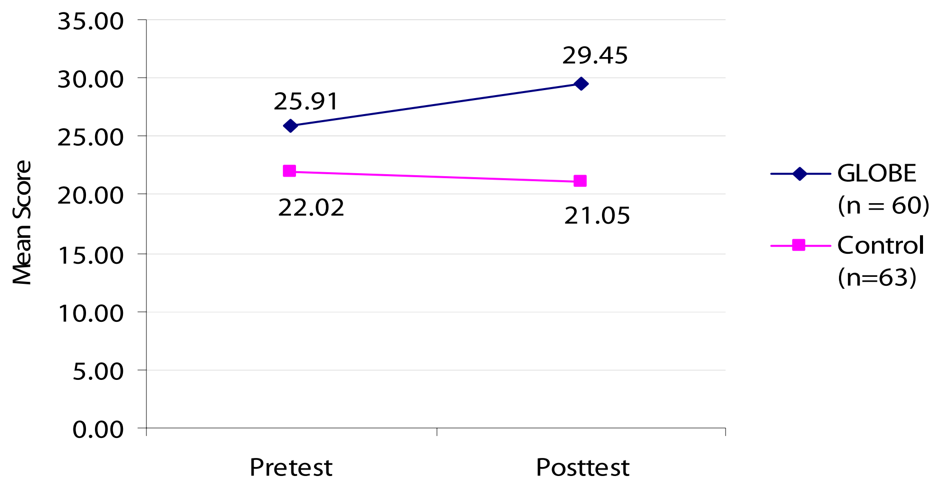


Table 5-3. Comparison of GLOBE and non-GLOBE Learning Outcomes Controlling for Pretest Scores

Source	Df	SS	MS	F	η2
Covariate: Pretest Scores	1	1279.73	1279.73	16.75*	.12
Group	1	1014.85	1014.85	13.28*	.10
Error	120	9169.14	52.31		
Total	122	11071.63			

*$p < .05$

Differences in Student Attitudes

A Cronbach's alpha was calculated for the 14 items concerning students' science attitudes. On the basis of this analysis, one item was dropped, and other items were grouped into three sub scales, as shown in Table 5-4.

Table 5-4. Student Attitudes toward Science Subscales

	Number of Items	Reliability	Maximum Score
Interest/value in learning science (e.g., "It is important to know science.")	7	.79	28
Belief in intrinsic/extrinsic factors that affect performance in science (e.g., "You have to have natural talent or natural ability to do well in science.")	4	.89	16
Preference of team work vs. working alone in science class (e.g., "I like working on a team in science class.")	2	.77	8
Total	13	.60	52

A *t*-test was performed to compare mean scores for each of the three attitude subscales, as well as the overall scale. Significant differences were not found in the mean scores between the two groups, indicating that GLOBE did not have much effect on student attitudes toward science in school and beyond.

Additionally, no correlations were found between the scores of the attitude toward science scales and the student learning gains and the mean gain scores in hydrology learning.

Discussion

The results of this study indicate that if a standard hydrology curriculum is supplemented with GLOBE, students will learn more about hydrology concepts and inquiry processes. Additionally, this study provides more detail about the specific form of GLOBE implementation that enhances student learning. It complements findings from a past study that found "data analysis activities" contributed to higher scores on students' scientific inquiry skills and understanding of science concepts (Penuel et al., 2003). Specifically, this study suggests that a mix of data collection across several protocols in a GLOBE topic, coupled with engagement in GLOBE learning activities and class discussion, can have a positive effect on student learning.

Importantly, both teachers were teaching their hydrology units in comparable ways, except that one teacher *augmented* her lesson with GLOBE activities that engaged students in data collection and discussion. The learning gains seem to have occurred largely from this lesson augmentation, supporting use of GLOBE as complementary curricular material. Considering the GLOBE teacher's background in teaching and studying informal environmental science, the teacher may have been uniquely prepared to augment her lessons with GLOBE activities, although this inference cannot be tested using data from this study.

The study failed to uncover any effects of GLOBE on students' attitudes toward science. This lack of effect suggests there was a mismatch between the broad attitudinal outcomes measured by these items and the relatively narrow attitudes that one unit involving GLOBE could reasonably influence. Another possibility is that it would take several different GLOBE investigations to affect student attitudes about science in general. Third, we collected data on attitudes only at the time of posttest, so initial attitude differences between the two groups are unknown. In the future, it may make sense to interview students to find out the specific ways that GLOBE may have affected their attitudes toward science rather than attempting to use broader measures.

This study yielded the strongest findings to date about the impact of GLOBE on learning. Compared with previous studies, we believe that we had more capacity in this study to design our investigation to reduce threats to validity (Shadish, Cook, & Campbell, 2002) associated with lack of control over GLOBE implementation quality and problems of teacher and student self-selection in study participation. Overall, this study provided an important lesson in the value of using careful design to study the impacts of a curricular supplement such as GLOBE.

Conclusion and Recommendations

GLOBE Data Reporting Levels Have Remained Constant

For the past several years, implementation levels as measured by overall data reporting levels have remained fairly constant. After an initial period of strong growth, GLOBE now appears to be training as many teachers who go on to report data as it is losing teachers who stop reporting data. The patterns also do not differ widely by investigation area: there is little evidence of strong growth or decline in data reporting in any particular area, except Soils.

This year, for the first time we examined honor roll schools in order to get a sense of how many schools were collecting the kind of data needed by scientists in particular investigation areas. Roughly 300 schools per year over the past 3 years made the honor roll for at least one area. The largest numbers were for Clouds and Hydrology, and there were fewer numbers of schools on honor roll for Soils or Land Cover/Biology. These patterns are consistent with overall patterns in data reporting levels. As with overall data reporting levels, moreover, the honor roll data have not shown significant growth in the past 3 years. In fact, the number of honor roll schools has declined slightly from 2001–02 to 2003–04 from 322 to 300.

GLOBE's Successful Partners Actively Facilitate Teacher Implementation

In 2002–03, we began a set of case studies of two successful partners in GLOBE in order to better understand how these partners function to support implementation. The partners were chosen because they have among the highest rates of data reporting, one index of implementation, and have developed comprehensive strategies for supporting teachers in the field. We already knew that some of the strategies they employed were associated with higher levels of data reporting from earlier studies (Penuel & Means, 2004), but through these case studies, we wanted to gain a better sense of how the partners implemented these strategies. The partners selected, GLOBE in Alabama and the University of Alaska Fairbanks (UAF), were full partners with us in the study. One partner leader, Elena Sparrow, helped us in preparing the research report and in presenting results of the study at a national conference. A version of the results will appear in 2005 in an issue of the journal *Science Education*.

Our case study research confirmed and extended our earlier research on the importance of mentoring (cf. Penuel & Means, 2004). As in earlier studies, we found that partners' work to mentor new and existing GLOBE teachers helped to support their implementation. The case studies provided evidence that some mentor activities with teachers were particularly useful. They helped teachers solve problems related to obtaining and setting up equipment. They reviewed standards and state curriculum frameworks with them face-to-face to explore opportunities for integrating GLOBE into their existing curriculum. They taught model lessons in the classroom, which helped teachers understand and implement GLOBE.

We found that student research was facilitated by partners largely to the extent that the partner emphasized it as a goal and provided incentives for student research. The Alaska partnership placed much more emphasis on research, and they provided some incentives to teachers to encourage them to have students conduct investigations that use GLOBE data. Several students in GLOBE did, some of which were selected to participate in the GLOBE Learning Expedition. The case study data lend some preliminary evidence to the idea that a partner must emphasize student research as a goal before the Program (at the partner or even national level) can expect students to produce more research using GLOBE data.

We also found that partners and teachers *both* did important work in helping to ensure a good fit between their local curriculum and GLOBE activities they chose to implement. GLOBE mentors may have had a better "birds-eye" view in some cases of the links between GLOBE activities and different concepts in state frameworks, but teachers knew best their own curriculum and demands placed on them at the school level. Conversations between mentors and teachers often facilitated clarity about various curriculum possibilities for particular teachers to implement with students.

Finally, we saw that even these successful partners faced challenges in sustaining their work. Although both continue to be successful, they have seen dramatic ups and downs in funding, and the funding sources have not stayed the same from year to year. Key to both partners' success has been strategic and policy-level partnerships that ensured them input into their state's decisions to broaden the science curriculum. It may be that other partners find this model challenging to adopt because they lack the time and resources to become more active politically, but the payoff for Alaska and Alabama partnerships has been particularly strong in this respect.

Teachers Use GLOBE Materials for Hands-On Supplementary Activities

In 2002–03, we conducted interviews with a sample of GLOBE teachers to learn more about how they use GLOBE's materials and Web site and integrate them into the classroom. These interviews were conducted to gain a better sense of how GLOBE can fit into different teachers' contexts and to identify a range of viewpoints about what aspects of GLOBE's materials are useful for teachers. In this small study, we found that teachers' use of materials reflected what they saw as GLOBE's primary benefit: providing students with the opportunity to do hands-on science following protocols. We also found, consistent with past case study research we have conducted, teachers supplement GLOBE materials with their own activities to teach the core concepts covered in protocols.

For this study, we relied on a small sample of seven experienced GLOBE teachers. All of them were veteran teachers with at least 7 years of teaching experience. They had all been implementing GLOBE for more than 2 years at the time of the interview and one of the teachers had been trained to be a GLOBE trainer. Such a small sample is not atypical for user testing with technology (Krug, 2000; Nielsen, 1999) and does illuminate the range of issues that users of materials and technologies encounter when they try to accomplish tasks that are important to them. It can also help to identify a range of ways teachers use materials and find them beneficial. At the same time, the sample is not sufficient to get a sense of how prevalent these issues are, especially among teachers who may find the materials so difficult to use that they choose not to implement GLOBE, since these kinds of teachers were not in the sample. Survey methods that draw on lessons learned from this study are more appropriate for learning about the prevalence of such issues.

The study found that teachers used instructions for carrying out protocols most often with students. The centrality of protocols in part reflects the chief benefit they see of the GLOBE materials: providing students with opportunities to do "hands-on" science. Some of the teachers explicitly commented that GLOBE protocols were much better than labs in their textbooks; in some cases, they replaced labs with data collection activities according to GLOBE protocols. At the same time, the focus on the protocols may also partly reflect a limitation that elementary school teachers saw in other parts of GLOBE materials. The background materials, as well as some learning activities, were seen as using language that was not appropriate for their students.

Teachers used many of the other elements of the Teacher's Guide—background information, directions, field guides, and diagrams—in planning lessons, but they did not rely on these materials in their teaching. Teachers used these materials to orient themselves when they first start with GLOBE and to remind them of aspects of the training and to help them select protocols to implement. For actual teaching, though, they presented students with materials on how to carry out protocols and not with other kinds of materials. Only the video was cited as helpful background shared with students; the video was cited by teachers as helpful in explaining to students the significance of the different protocols.

Two types of materials that were *not* widely used by teachers are important to consider. Teachers said they did not use the standards alignment charts in the back of the Guide, although they did concede that as accountability pressures increase, they might be more inclined to do so in the future. Instead, teachers used their own familiarity with their local standards to make quick judgments on alignment, simply by looking at the activities. In addition, they rarely used the Web site to do much more than report data. The paper guide was valuable to them, because they could flip through it easily to select activities. Teachers' many suggestions for improving the Web site suggest it may not be as useful in meeting their needs as a site for promoting teacher or student learning.

None of the teachers we interviewed used the GLOBE materials alone when teaching a unit or lesson. Importantly, they supplemented GLOBE with other material from their textbook or from material they had obtained from other programs and the Internet. One reason why teachers combine GLOBE with other materials in the classroom is that the Program fits well with other activities. On the flip side, report elementary teachers, its materials are not always useful in teaching the core concepts or big ideas behind the protocols or the units they must teach.

Hands-On Data Collection Makes a Difference for Hydrology Learning

In the 2003-04 evaluation study, we worked collaboratively with the partnership in North Carolina to investigate GLOBE's effects in hydrology. SRI evaluations have not investigated hydrology learning systematically in recent years, in part because we could not recruit classrooms to participate. We decided to conduct a small, focused study to examine the effects of engaging in GLOBE hydrology data collection, reporting, and analysis on middle-school students. The study focused on eighth grade students (n = 123) in classes taught by two different teachers in the same school. Importantly, both teachers were expected to teach the same 10–11 week units on hydrology, and the main difference between the two conditions was that one class, in addition to learning about hydrology concepts in class, engaged in GLOBE activities.

The results of our quasi-experimental study suggest that GLOBE data collection can make a difference for students' learning of key hydrology concepts tested on our assessment. The

GLOBE group mean performance score increased from the pretest to the posttest a significantly larger amount than the group mean of the non-GLOBE sample ($p < .001$). The effect size was roughly half of a standard deviation ($d = .49$), a relatively large effect for an educational intervention. At the same time, we saw no effect on students' attitudes toward science for this brief intervention.

The study provides evidence that when students collect data from multiple protocols in hydrology in conjunction with participating in teachers' existing lessons on hydrology concepts, students can make significantly greater gains than when those lessons are implemented without GLOBE. Moreover, the study found significant gains resulted from a modest implementation level. The GLOBE teacher in the study did not use GLOBE protocols every day, and used just two learning activities with students. She discussed the GLOBE data a few times, providing students with a broad experience of the Program's activities without using it exclusively in her curriculum. It would be valuable to know whether similar modest thresholds of implementation could yield significant results in other investigation areas, especially Atmosphere, since most students who participate in the Program collect data and engage in learning activities in this area.

The results of this study provide no definitive evidence that GLOBE caused the increase in student achievement. An experimental design with random assignment is necessary to justify such claims. Moreover, the two teachers did differ in their preparation to teach environmental science, which may have led the GLOBE teacher to be more effective in presenting the lessons. At the same time, several characteristics of the treatment and comparison groups were equivalent (e.g., same level of exposure to hydrology content, student characteristics), and statistical controls were used to adjust for pretest differences in individual student achievement. For this reason, we can be more confident in the results than we would be with a pre-post design with a single treatment group or from a posttest only design with no pretest or "proxy" pretest at all (Shadish et al., 2002).

Recommendations Based on Findings from this Report

Below, we outline five recommendations that are based in part on findings from this report. In crafting these recommendations, we have also drawn on our own experience with GLOBE over the years and have sought to refine and revise our suggestions for the Program to meet today's demands for it.

Recommendation 1: Develop a repertoire of successful strategies for curriculum integration.

In the past, the Program's strategy for promoting curriculum integration has focused on creating maps showing alignment of GLOBE with national standards. At present, new efforts are underway to redesign training opportunities to reflect better the kinds of units and standards that teachers typically teach at different levels. In addition to these efforts, GLOBE might consider developing a wider repertoire of strategies to help teachers address the enduring problem of promoting curricular integration. The successful partners we visited as part of our case study are characterized by the breadth of strategies they employed for supporting this goal.

It is important that some of these strategies be ones that partners can undertake in face-to-face settings with teachers. The examples from Alabama in particular stand out: mentors and teachers there sit down together, to discuss state frameworks and local curricula together, working out the ways in which GLOBE fits and may need to be adapted to local circumstances. A key assumption here is that such face-to-face alignment will necessarily result in a creative adaptation, rather than wholesale or even faithful implementation of the Program. Past research suggests that whenever a program like GLOBE is implemented, it is transformed in the process of localization by teachers (Barab & Luehmann, 2003). That local adaptation should be viewed as a strength of the Program, and it is best supported when knowledgeable mentors work side by side with teachers.

Recommendation 2: Help partners structure incentives for outcomes they seek.

Both partnerships we studied set clear goals for their partnerships with respect to implementation (Alabama and Alaska) and student research (Alaska). Alaska in particular tied implementation to course credit, and provided teachers and students with opportunities to showcase student research results. By contrast, some other partnerships have provided incentives at the time teachers have been trained, with few positive results. Teachers have completed training, but then they have not gone on to implement GLOBE.

There are many different ways to structure incentives to promote GLOBE implementation. Tying stipends for training to data reporting levels or to formal reports of student participation in learning activities is one strategy. Providing additional equipment to teachers who implement protocols in a particular investigation area is another. Helping pay for spots to science fair competitions provides an incentive for student research with GLOBE. Although it is unlikely a partner will be able to pay for all of these kinds of incentives, it is worth considering how key incentives that are currently offered to teachers (such as defraying costs of participating in training) might be restructured to be offered after teachers and students have had a chance to participate in GLOBE activities in the classroom.

Recommendation 3: Identify materials and programs that are most commonly used in conjunction with GLOBE.

A key finding from our materials study and from previous research is that teachers use GLOBE in combination with many other materials. GLOBE has never sought to be a stand-alone curriculum. Its strength, from teachers' point of view is as a supplement to their existing curriculum or as a replacement for hands-on activities and labs provided to them as part of their regular text books. It may be that the materials GLOBE teachers use are idiosyncratic and vary from state to state. At the same time, in our site visits we often hear the same programs come up time and again, such as JASON and Project WET. Already, many partners have relationships with these programs.

As GLOBE considers its future, partnerships with organizations whose materials teachers use may be a fruitful way to extend its reach. It may be that those partners could facilitate the distribution of GLOBE protocols and training in them. Those partners, when providing mentoring to teachers in their other programs, could also help teachers with implementing GLOBE. Any number of possible arrangements could facilitate a renewal in GLOBE's growth, provided the partnerships are structured to provide mutual benefit to the parties involved.

Recommendation 4: In re-designing the Web site, consider it as a potential site for extending learning in GLOBE.

GLOBE is currently planning a redesign of its Web site, which presents several challenges and opportunities for the Program. On the one hand, GLOBE's Web site must meet many different demands of its diverse stakeholders, which include scientists, educators, partners, and students. At present, educators with whom we have spoken do not make extensive use of the Web site in their teaching. Several educators in our materials study made recommendations for including more on the Web site that enabled *students* to extend their learning in GLOBE. Interactive applets that allow students to explore GLOBE concepts, hone their measurement skills, and practice with data analysis could provide additional reasons for teachers to use the Web site. Importantly, such additions could make the Web site a more integral feature of their GLOBE implementation efforts, which may increase its use for reporting data, learning about GLOBE events and field campaigns, and collaborating with other schools and scientists.

Recommendation 5: Suggest to partners and educators an ideal starting level of implementation, to help guide new GLOBE teachers.

Almost without exception, when we ask teachers in interviews what advice they have for teachers new to GLOBE, they always say, "Start small, start somewhere." GLOBE presents a sometimes overwhelming array of choices for teachers. Although teachers' own curriculum provides important constraints on what they can implement, the Program still has many learning opportunities within each investigation area. In the past, the Program has emphasized teacher choice but given few guidelines as to combinations of activities that might lead to improved achievement.

From the past two studies of student learning we have conducted (Year 7, Year 9), we are beginning to gain a better understanding of what aspects of GLOBE implementation contribute to student learning on measures that are aligned with GLOBE goals. Although this information is partial because it covers only two investigation areas and because the research designs do not permit us to make causal claims, they provide some converging evidence of important implementation factors that could be translated into guidance for partners.

A primary recommendation we would make at this point is that data analysis makes some contribution to learning and is an important place for teachers to begin. Data analysis was part of the GLOBE experience of this year's study, and past results from hierarchical linear modeling analysis suggest that data analysis made a significant contribution to conceptual learning and to students' inquiry skills. Data analysis, at the same time, is not often pursued by teachers for a variety of reasons, including lack of time. Yet our results also show that even a modest amount of looking at data may yield achievement gains.

In 2004–05, we are investigating further what factors in implementation contribute to GLOBE learning through a large 50-classroom comparison group study. We plan to analyze the contribution of GLOBE learning activities and data collection, reporting, and analysis to student conceptual knowledge and inquiry skills in the Atmosphere investigation area. For this study, we are testing a model in which we recommend to teachers a modest level of implementation with students, in order to test further the theory that such recommendations can be made successfully to GLOBE teachers.

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GLOBE Partner Interview Guide
Spring 2003

1. Background and goals

- How did you get started as a GLOBE partner? (month and year of MOU, month and year of first training)
- What are your goals for your GLOBE partnership? If I were to talk with you 5 years from now, what would you like to be able to say you accomplished for teachers and for the GLOBE program?
- How many teachers have you trained to date? How many would you like to work with in a given year? *(including training and any other forms of support)*
- *(if not answered already:)* What is "success" in working with a teacher? *(i.e. they are trained; they report data this year; they report data steadily; their students learn from interesting GLOBE-related activities…)*

2. Activities and supports

- What types of support programs do you offer teachers? *Probe for any of the following that aren't offered:*
  - Teacher recruitment
  - Training
  - Support for curriculum or standards integration
  - Localization of GLOBE science; contacts/partnerships with local scientists
  - Other post-implementation support
  - Networking opportunities with other teachers
  - Advocacy (e.g. working with state standards to promote environmental science)
  - Financial support, equipment, or other incentives
- How are trainings conducted? e.g. week-long sessions that cover all protocols, a 4-week Saturday series each focusing on a different topic, etc. What are your goals for training? To what extent to you tailor or supplement the training program and materials provided by GLOBE?
- For each additional activity the partner listed above, probe for:
  - Description of the program/how it is conducted
  - What strategies have been the most and least successful. *Pay particular attention to any strategies that seem unique and potentially useful for other partners; for these, make sure you get a full description of what the partner does, how, and with what results.*

- *If the partner does not provide explicit post-training supports, ask:*
  What kind of follow-up do you have with teachers after they leave the workshop? Do you know who's implemented GLOBE and in what ways?

3. Partner organization and capacity

- What organization is this partnership affiliated with (e.g. a university, a museum)? How tight is that affiliation?
- How are you staffed? *(number of in-house staff; consultants or volunteers)* Have you experienced any challenges in finding qualified staff, or in staff turnover?
- How are you funded? *(probe for sources and amounts of grants)*
- What relationships do you have that allow you to do what you do? *(e.g. partnerships with local community organizations)* In what ways do those benefit your work?
- Do you have sufficient capacity (people, money, connections) to carry out your mission? What strategies have you tried for increasing capacity? Do you have any advice for other partners that are struggling to find the time and money to carry out their programs?

4. Relationship with the GLOBE program office

- What do you think are the GLOBE program's goals for your partnership? What seems to be most important to them? How well does that fit with your way of looking at the partnership?
- What supports and information does GLOBE provide that are useful to you?
- What additional supports do you wish they would provide?
- How effectively are challenges and strategies shared across partners? Do you feel that community is facilitated among partner organizations?

5. Challenges

- What do you see as the biggest challenges for teachers as they implement GLOBE?
- What are your own biggest challenges? Is there anything we haven't talked about that you've done to overcome those challenges?
- How do you decide how well you're doing? Do you do any sort of evaluation of your programs? If so, how do you do that, and what data do you look at?

6. Close

- What benefits do you get from being a GLOBE partner? Are you glad you're doing this?
- What's next for your partnership?

Classroom Observation

A. Teacher's Plans and Goals *(Complete this section with the teacher prior to the observation.)*

Source of activity *(i.e., GLOBE, teacher, student)*:

Brief description of activity planned including time frame:

Intended learning outcomes:

Purpose for selecting participants if not all students participate:

Frequency of activity with these and other students:

Connection of this activity to previous and future activities:

Ways of assessing student outcomes for this activity:

B. Observation Overview *(One researcher can complete the next two sections during the observation. The other researcher can record a narrative chronological account of what is happening.)*

DATE:	_________________________	CLASS:	____________________________
SCHOOL:	_________________________	GRADE(S):	____________________________
TEACHER:	_________________________	# STUDENTS:	____________________________
START TIME:	_________________________	FINISH TIME:	____________________________

Demographic composition of students in class:

Other adults present *(e.g., parent, classroom aide, another teacher)*:

Physical description of site *(i.e., classroom, GLOBE study site, as applicable)*:

Narrative description of activity observed:

B (cont.). Instructional Events and Interactions Observed

Content: *Indicate the GLOBE topics and concepts that students seem to be learning or using, and note the teacher's framing of these. Describe additional topics and concepts (in science, math, or other subject areas) that students seem to be learning or using, and note the teacher's framing of these.*

Performance: *Describe skills and actions (in GLOBE, science, math, or other subject areas) that the students seem to be learning or using, and note the teacher's framing of these.*

Materials: *List the materials such as GLOBE equipment and teacher-created items used in the activity.*

B (cont.). Instructional Events and Interactions Observed

Teacher role(s): *Comment on the teacher's actions in terms of leading/facilitating/monitoring the activity.*

Student role(s): Comment on the student's actions in terms of observing/completing/organizing the activity.

Student Engagement: What percentage of students participating seemed engaged in the activity? Describe any off-task activities of students, and any snags experienced by the teacher.

Diversity: Describe any observations that reflect particular sensitivity or insensitivity toward of diversity among students (e.g., their gender, race/ethnicity, and/or cultural background).

Assessment: *Indicate the teacher's actions in terms of assessing student performance.*

C. Inquiry Rating *(Complete the next section following the observation.)*

1= addressed in activity- student's active learning
2= addressed in lecture
3= addressed in student materials

GLOBE Inquiry Concepts	**1**	**2**	**3**
Set up a new, appropriate problem/application			
Pose relevant questions and develop hypotheses			
Make and test predictions			
Make observations and measurements that are accurate and appropriate			
Use equipment properly with appropriate safety procedures			
Use quality assurance procedures (multiple readings; recalibration) and detect measurement errors			
Specify measurements and variables			
Identify similarities and differences			
Explain reasons for differences			
Use appropriate mathematical procedures			
Infer patterns and trends			
Explain data and relationships using evidence			
Collect and organize data			
Use multiple forms to represent data			
Use models and simulations			
Communicate findings			

GLOBE Materials Review
Phone Script for Screening Teachers

Contact Information

Teacher's Name ______________________________School _________________________________

City and State ________________________________Phone Number _________________________

Introduction

Hello, may I please speak to ____?

My name is _________________________________. I'm calling from the Center for Technology in Learning at SRI International. We're researching the GLOBE program and specifically looking at how the GLOBE curriculum materials can be improved. Do you have a few moments or would you prefer that I call you at a more convenient time?

(If teacher requests that we call at another time, jot down contact information below)

Day______________________________ Time ______________

Phone number (if different) _________________________________

Protocol

1. We are particularly interested in the materials for Atmosphere and Hydrology. Have you used the GLOBE materials for Atmosphere and Hydrology this year?

YES ***(Skip to Question 2)***

NO ***(Go to Question 1a)***

1a. Do you PLAN to use the GLOBE materials for Atmosphere and Hydrology either this year or next year?

YES ***(Read below and Skip to Other Contacts on the Last Page)***
For this study, we are looking to talk to teachers who are currently implementing GLOBE. If it is okay with you, we may be contacting you again in the future.

NO ***(Skip to Other Contacts on the Last Page)***

2. What protocols and activities have you used this year from Atmosphere and Hydrology?

(Check off the items that are mentioned. Prompt for learning activities if none are mentioned. Interviewer must be somewhat familiar with protocols and activities if questions are asked.)

	Atmosphere Protocols		**Atmosphere Activities**
	Cloud Protocols		Observing, Describing, and Identifying Clouds
	Aerosol Protocol		Estimating Cloud Cover – A Simulation
	Barometric Pressure Protocol		Observing Visibility and Sky Color
	Relative Humidity Protocol		Making a Sundial
	Precipitation Protocols		Calculating Relative Air Mass
	Maximum, Minimum, and Current Temperature Protocol		Studying the Instrument Shelter
	Digital Multi-Day Air and Soil Temperatures Protocol		Building a Thermometer
	Surface Ozone Protocol		Cloud Watch
	Automated Soil and Air Temperature Monitoring Protocol		Constructing a Model of Parts Per Billion of Surface Ozone
			Making a Contour Map
			Draw Your Own Visualization
			Learning to Use Visualizations

	Hydrology Protocols		**Hydrology Activities**
	Water Transparency Protocol		Water Walk
	Water Temperature Protocol		Model Your Watershed
	Dissolved Oxygen Protocol		Water Detectives
	pH Protocol		pH Game
	Electrical Conductivity Protocol		Practicing the Protocols
	Salinity Protocol		Water, Water Everywhere. How Does it Compare?
	Optional Salinity Titration Protocol		Macroinvertibrate Discovery
	Alkalinity Protocol		Modeling Your Water Balance
	Nitrate Protocol		

Other ____

____

3. Did you have any problems acquiring or using the equipment that you needed for GLOBE this year?

____

____

4. Do your students usually access the Internet when they do GLOBE?

____

____

5. When your students do GLOBE- do they focus more on data COLLECTION or data ANALYSIS?

____

____

Those are all of the questions I have for now. Since you seem familiar with the GLOBE program, we would love to include you in our study. If you agree to participate, the next steps would be for us to send you a short survey and then to meet with you at your school for about an hour. As a thank you for your time, you will receive a $30 gift certificate from Amazon.com. Are you willing to participate?

YES *(See Below)*

NO (*Make sure the teacher has not refused because of a misunderstanding, etc.)*

If the teacher says YES:
The survey should take about ten minutes of your time and will help us better prepare for the interview. Would you prefer I send it to you in the mail, by email or both?

MAIL (*Ask for mailing address)* **EMAIL ((*Ask for email address)***

______________________________________ ___________________________

____

Thank you. We will be sending out the survey in the next few days. When would be a convenient time for us to visit with you at your school?

DATE **TIME**

_________________________________ ______________________

ASK FOR OTHER CONTACTS

Other Contacts

Do you know of any other teachers that have used Atmosphere or Hydrology this year who would like to share their experience to help us better determine how GLOBE materials can be improved?

(If YES, ask for contact information)

Teacher's Name ______________________________School ________________________________

City and State ________________________________Phone Number _________________________

Teacher's Name ______________________________School ________________________________

City and State ________________________________Phone Number _________________________

Teacher's Name ______________________________School ________________________________

City and State ________________________________Phone Number _________________________

Thank you so much for your time and have a wonderful day.

Pre-Interview Survey For GLOBE

(Reformatted from zoomerang.com to Microsoft Word)

1. Your Name

2. Your School Name

3. What grade level(s) do you teach? (Check all that apply)
   - o Primary (K-3)
   - o Elementary School (3-5)
   - o Middle School (6-8)
   - o High School (9-12)

4. What subject(s) do you teach? (Check all that apply)
   - o All Subjects (Self-Contained Classroom)
   - o General Science
   - o Earth Science
   - o Biology
   - o Chemistry
   - o Physics
   - o Other, Please Specify

5. Please rate the academic level of most of your students.
   - o Above grade level
   - o At grade level
   - o Below grade level
   - o Mixed-ability

6. **Teaching context**

(1)	(2)	(3)	(4)	(5)
Very high	High	Moderate	Minimal	None

- Please rate the level of flexibility you have in deciding what to include in your science curriculum.
- Please rate the level of flexibility you have in deciding how to teach the topics in your science curriculum.
- Please rate the level of emphasis on standards and testing at your school.
- Please rate the level of emphasis on hands-on science in your department and/or school.
- Please rate the level of emphasis on inquiry science in your department and/or school.

7. When did you receive GLOBE training?
   - o 2002
   - o 2001
   - o 2000
   - o Prior to 2000

8. What type of training did you receive for GLOBE?

- o Training by the central office for GLOBE
- o Training by a regional GLOBE partner
- o Other, please specify

9. How useful are the following in helping you to implement GLOBE protocols and activities?

(3) Very Useful	(2) Somewhat Useful	(1) Not Useful

- ▪ GLOBE Teacher's Guide (Hard copy)
- ▪ GLOBE Teacher's Guide (Online)
- ▪ Material received from partner training
- ▪ Material that other teachers created
- ▪ Material that you created

10. What edition of the Teacher's Guide do you have? (The year should be either on the front cover or on the first page of your guide)

11. How frequently do you use the GLOBE Help Desk online?

- o Often (Weekly)
- o Sometimes (Monthly)
- o Rarely (1-5 times per year)
- o Never

12. For the protocols and activities that you have implemented, please indicate which sections of the Teacher's Guide you use and have seen.

(3) Have Used	(2) Have Seen But Have Not Used	(1) Have Not Seen

- ▪ Matrix correlating GLOBE activities and National Science Education Standards
- ▪ Introduction (Big Picture)
- ▪ Gray boxes (Purpose, Overview, etc.)
- ▪ Step-by-step directions

13. For the ATMOSPHERE INVESTIGATION, please answer whether you are currently implementing, have implemented in the past, or have never implemented the following PROTOCOLS.

(3) Implementing this Year	(2) Not Implementing this Year But Have Implemented in the Past	(1) Never Implemented

- Cloud Protocols
- Aerosol Protocol
- Barometric Pressure Protocol
- Relative Humidity Protocol
- Precipitation Protocol
- Maximum, Minimum, and Current Temperature Protocol
- Multi-Day Air and Soil Temperatures Protocol
- Surface Ozone Protocol
- Automated Soil and Air Temperature Monitoring Protocol

14. For the ATMOSPHERE INVESTIGATION, please answer whether you are currently implementing, have implemented in the past, or have never implemented the following ACTIVITIES.

(3) Implementing this Year	(2) Not Implementing this Year But Have Implemented in the Past	(1) Never Implemented

- Observing, Describing, and Identifying Clouds
- Estimating Cloud Cover
- Observing Visibility and Sky Color
- Making a Sundial
- Calculating Relative Air Mass
- Studying the Instrument Shelter
- Building a Thermometer
- Cloud Watch
- Constructing a Model of Parts Per Billion of Surface Ozone
- Making a Contour Map
- Draw Your Own Visualization
- Learning to Use Visualizations

15. For the HYDROLOGY INVESTIGATION, please answer whether you are currently implementing, have implemented in the past, or have never implemented the following PROTOCOLS:

(3) Implementing this Year	(2) Not Implementing this Year But Have Implemented in the Past	(1) Never Implemented

- Water Transparency Protocol
- Water Temperature Protocol
- Dissolved Oxygen Protocol
- pH Protocol
- Electrical Conductivity Protocol
- Salinity Protocol
- Optional Salinity Protocol
- Alkalinity Protocol
- Nitrate Protocol

16. For the HYDROLOGY INVESTIGATION, please answer whether you are currently implementing, have implemented in the past, or have never implemented the following ACTIVITIES:

(3) Implementing this Year	(2) Not Implementing this Year But Have Implemented in the Past	(1) Never Implemented

- Water Walk
- Model Your Watershed
- Water Detectives
- pH Game
- Practicing the Protocols
- Water, Water Everywhere. How Does it Compare?
- Macroinvertebrate Discovery
- Modeling Your Water Balance

17. Any other comments

GLOBE Materials Review
Interview Protocol

I. Teacher's Information

Use the survey responses to fill out this page prior to the interview. At the beginning of the interview, verify the information (or have the teacher complete the survey if they have not done so). Based on the teacher's implementation and preference, choose to focus either on Atmosphere or Hydrology. Questions for the Atmosphere Investigation are in Section IV. Questions for Hydrology are in Section V. All teachers should answer Section II and III.

Teacher's Name **School**

City and State **Phone Number**

Grade Level(s) **Subject(s)**

Number of Years Implementing Globe **Date of Interview**

	Atmosphere Protocols		**Atmosphere Activities**
	Cloud Protocols		Observing, Describing, and Identifying Clouds
	Aerosol Protocol		Estimating Cloud Cover – A Simulation
	Barometric Pressure Protocol		Observing Visibility and Sky Color
	Relative Humidity Protocol		Making a Sundial
	Precipitation Protocols		Calculating Relative Air Mass
	Maximum, Minimum, and Current Temperature Protocol		Studying the Instrument Shelter
	Digital Multi-Day Air and Soil Temperatures Protocol		Building a Thermometer
	Surface Ozone Protocol		Cloud Watch
	Automated Soil and Air Temperature Monitoring Protocol		Constructing a Model of Parts Per Billion of Surface Ozone
			Making a Contour Map
			Draw Your Own Visualization
			Learning to Use Visualizations

	Hydrology Protocols		**Hydrology Activities**
	Water Transparency Protocol		Water Walk
	Water Temperature Protocol		Model Your Watershed
	Dissolved Oxygen Protocol		Water Detectives
	PH Protocol		pH Game
	Electrical Conductivity Protocol		Practicing the Protocols
	Salinity Protocol		Water, Water Everywhere. How Does it Compare?
	Optional Salinity Titration Protocol		Macroinvertibrate Discovery
	Alkalinity Protocol		Modeling Your Water Balance
	Nitrate Protocol		

3 – Implementing this year 2 – Implemented in the past

II. Overview (5-10 Minutes)

Before asking the questions, explain the purpose of the research and that the structure of the interview will move from general to specific questions.

1. How did you become involved with GLOBE?

Probe: a. Have you had experience with hands on or experiential science before using GLOBE?

2. Can you give a very general overview of how GLOBE is implemented both school wide and in your classroom?

Probe: a. How many teachers were trained and how many teachers use GLOBE?

b. When and how often do you teach GLOBE?

c. Do you teach GLOBE to your whole class, in small groups, as part of a club?

d. How do you integrate GLOBE with the rest of your curriculum?

GLOBE Materials Review
Interview Protocol

III. General Usage of GLOBE Materials (20 minutes)

1. Consider a teacher new to GLOBE, based on your experience, what materials would you suggest they look at to get started?

2. What are some of the best ways that you and other teachers you know have found to introduce GLOBE to the students?

3. How do you go about choosing the GLOBE protocols and activities that you use with your students?

Probe: a. Are the matrices showing the correlation of GLOBE activities with National Science Education Standards useful?

b. Are the gray boxes useful in providing an overview of the lesson?
- i. Are the student outcomes, science concepts, and scientific inquiry abilities aligned to objectives in your curriculum?
- ii. Based on the suggested level of the material, have you been able to select material that is appropriate for your students?

4. How do you adapt GLOBE to the different levels and learning styles of your students?

5. Do your students respond differently to the GLOBE materials than they do to textbook materials?

6. Have you created any of your own materials to teach GLOBE (Handouts, worksheets, posterboards?)

Probe: a. What were you able to address by developing your own materials that the curriculum guide was lacking?

b. We may be able to use your ideas to improve the GLOBE materials. May I see the materials and/or have a copy?

7. Do you give any tests or outside assignments relating to GLOBE?

8. From reading the curriculum materials, is it obvious why data from the protocols would be of interest to scientists?

9. For any of the Investigations, were there any protocols or activities that you chose not to implement or had trouble implementing due to problems with the curriculum materials?

Probe: a. Which protocols and/or activities were problematic and why?

b. Do you have suggestions for how they could be improved?

10. Have you used the student investigations page on the GLOBE Web site?

Probe: a. If so, how has it been useful to you?

b. Do you have suggestions for improvement?

III. ATMOSPHERE INVESTIGATON (20 - 25 Minutes)

1. Which materials do you find most useful for implementing the ATMOSPHERE Investigation?

Probe: a. Do you rely mostly on the hard copy of the teacher's guide, the online teacher's guide, information from partners, teacher created materials, other?

b. What makes these materials particularly useful?

If teacher mentions materials not published by GLOBE, ask to see and/or have a copy of them, as they might be useful for improving the GLOBE materials.

2. Consider teachers new to GLOBE, how would you advise them to use the introductory materials of the teacher's guide?

Probe: a. How is the information best conveyed to students? (Copy it for them to read, explain it to them verbally, etc.)

i. Why have you found that to be the most effective approach?

b. Is the section on Measurements useful? ***(Introduction Pages 4-9)***

c. Is the Getting Started section useful in planning? (***Introduction Pages 9-16)***

d. Is it clear which sections are written for teachers and which are for students?

e. What reading level do the introductory materials seem to be appropriate for?

f. Do you have suggestions for how the Introduction can be improved?

3. For someone who is just getting started- constructing instruments, selecting a site, and setting everything up, what resources and materials would be valuable?

Probe: a. Are the written instructions and diagrams useful for construction?

b. Is the section on site selection and set-up useful?

c. Is the section on documenting the atmosphere study site useful?

d. Are the field guide and related worksheets useful?

e. Do you have suggestions for how this section can be improved?

4. For someone who is using the one of the protocols for the first time in the classroom, what suggestions do you have? (*Turn to one or two for an example)*

Probe: a. How are the gray boxes useful?

b. How would teachers use the Introduction?
   i. Would it be useful for teachers and/or students to read?
   ii. What reading level are the materials appropriate for?

c. Is the Teacher Support section helpful for lesson preparation?

d. Are photocopies of the Lab Guides, Field Guides, Preparation Guides, and/or Data Sheets sufficient for getting students started?
   i. Are the instructions clear and thorough enough?
   ii. What grade level and reading level are the materials appropriate for?

e. Can the Looking at Data section be used to help students process their findings?
   i. Is it useful for teachers and/or students to read?
   ii. Are the diagrams, graphs, and/or tables useful?
   iii. What reading level are the materials appropriate for?

f. Do you have suggestions for how the general protocol structure can be improved?

5. For someone who is using one of the activities for the first time in the classroom, what suggestions do you have? *(Turn to one or two for an example)*

Probe: a. How are the gray boxes useful?

b. Are the background information, instructions, and/or diagrams useful in implementing this activity?
   i. What suggestions might you have for conveying this information to students? (Copy it for them to read, explain it to them verbally, etc.)
   ii. How is that approach useful?

c. *If applicable to this activity*
Are photocopies of the Data Sheets, Activity Sheets, and/or Summary Charts sufficient for leading student activities?
   i. Are the instructions clear and thorough enough?
   ii. What grade level and reading level would the materials be appropriate for?

d. Do you have suggestions for how the general activity structure can be improved?

IV. HYDROLOGY INVESTIGATON (20-25 Minutes)

1. Which materials do you find most useful for implementing the HYDROLOGY Investigation?

Probe: a. Do you rely mostly on the hard copy of the teacher's guide, the online teacher's guide, information from partners, teacher created materials, other?

b. What makes these materials particularly useful?

***If teacher mentions materials not published by GLOBE, ask to see and/or have a copy of them*. *as they might be useful for improving the GLOBE materials*.**

2. Consider teachers new to GLOBE, how would you advise them to use the introductory materials of the teacher's guide?

Probe: a. Is duplicating and distributing the Scientists Interview helpful to the students? ***(Welcome Pages 6-11)***

b. How can the information in the Big Picture be conveyed to students? (Copy it for them to read, explain it to them verbally, etc.) ***(Introduction Pages 1 – 5)***

i. How is that approach useful?

c. Are the sections Preparing for the Field, Overview of Activities, Student Learning Goals, and Student Assessment useful in planning an approach to this Investigation? (***Introduction Pages 6 - 7)***

d. Is it clear which sections are written for teachers and which are for students?

e. What reading level do the introductory materials seem to be appropriate for?

f. Do you have suggestions for how the Introduction can be improved?

3. For someone who is just getting started- selecting a site and setting everything up, what resources and materials would be valuable?

Probe: a. Is the section on *Preparing For Your Hydrology Measurements* useful? ***(Protocols Pages 2 –4)***

b. Is the *Collecting the Water Sample* section useful? ***(Protocols Pages 5 – 6)***

c. Do you have suggestions for how this section can be improved?

4. For someone who is using one of the protocols for the first time in the classroom, what suggestions do you have? (*Turn to one or two for an example)*

Probe: a. How are the gray boxes useful?

b. How can the step-by-step directions and/or diagrams be useful in conducting the protocol? (Read it and guide students through the process, copy it for them to read, etc.)
   - i. Are the instructions clear and thorough enough?
   - ii. What grade level and reading level are the materials appropriate for?

c. Are students able to use the Data Sheets?
   - i. Are the instructions clear and thorough enough?
   - ii. What grade level and reading level are the materials appropriate for?

d. Do you have suggestions for how this protocol (or the general protocol structure) can be improved?
   - i. Would more background information be useful?
   - ii. Would more information on classroom implementation be useful?
   - iii. Would information on data analysis be useful?

5. For someone who is using the one of the activities for the first time in the classroom, what suggestions do you have? (*Turn to one or two for an example)*

Probe: a. How are the gray boxes useful?

b. Are the background information, instructions, and/or diagrams useful in implementing this activity?

c. What suggestions might you have for conveying the information to students? (Copy it for them to read, explain it to them verbally, etc.)

d. Are the ideas for adapting and supplementing the activities useful?
   - i. Are the adaptations for younger and older students appropriate?
   - ii. Does the *Further Investigations* section provide good ideas?
   - iii. Does the *Student Assessment* section provide reliable assessment ideas?

e. ***If applicable to this activity***
Are students able to use the Data Sheets, Activity Sheets, and/or Summary Charts if they are just photocopied pages for their use?
   - i. Are the instructions clear and thorough enough?
   - ii. What grade level and reading level are the materials appropriate for?

f. Do you have suggestions for how this activity (or the general activity structure) can be improved?

Section A: Test of Background Knowledge

Instructions: On the following pages, you will be asked several questions about topics you may have studied in science this year. Some of the questions may be difficult to answer, but do the best you can to answer each question correctly. Circle the letter next to the correct answer for each question.

1. Four groups of students from Ms. Hill's class measured water temperature in a creek near their school. Each group recorded a final, official measurement. Their water temperature measurements are presented in the table below.

	Group 1	**Group 2**	**Group 3**	**Group 4**
First temperature reading	12 °C	12.50 °C	12 °F	12 °C
Second temperature reading	12 °C	No record	10 °F	13 °C
Third temperature reading	13 °C	No record	8 °F	12 °C
Temperature recorded	12.3 °C	12.50 °C	10 °F	26 °C

Which group or groups **collected** and **recorded** the water temperature readings correctly?

a. Group 1
b. Group 4
c. Groups 1 and 2
d. Group 3

2. When you buy a fish, you are advised to place a plastic bag containing both the new fish and its original water into the new tank or pond for a few minutes. Why is this important?

a. To let the fish bacteria die first so the new pond water remains clean
b. To prevent shock to the fish from sudden water temperature change
c. To let the fish observe its new environment from a protected spot
d. To learn to be patient with animals as they adapt to new home.

3. There used to be a lot more life in a stream than now. Changes in ___________ are most likely the cause of the drop in aquatic life. (Choose one answer choice below to fill in the blank.)

a. Nitrates
b. Salinity
c. Turbidity
d. Dissolved oxygen

Explain your answer choice.

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4. You are testing the pH of water. After careful testing, you observe that the pH of the water is 7. How would you characterize the acidity level of the water based on this reading?

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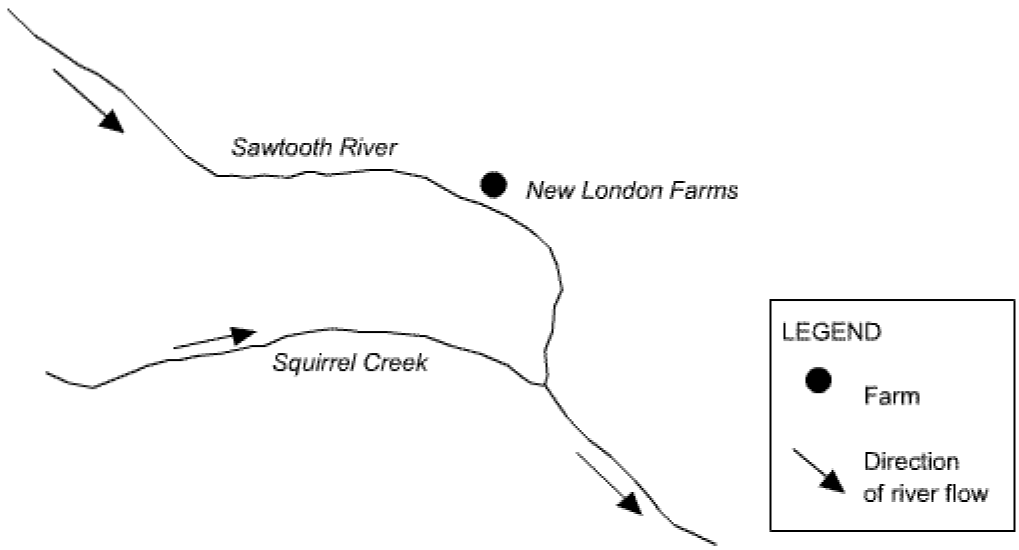
5. Forest rangers want to find out whether new trees on a hillside are reducing the amount of soil that washes into the river.

What should they measure to see if the trees are preventing erosion?

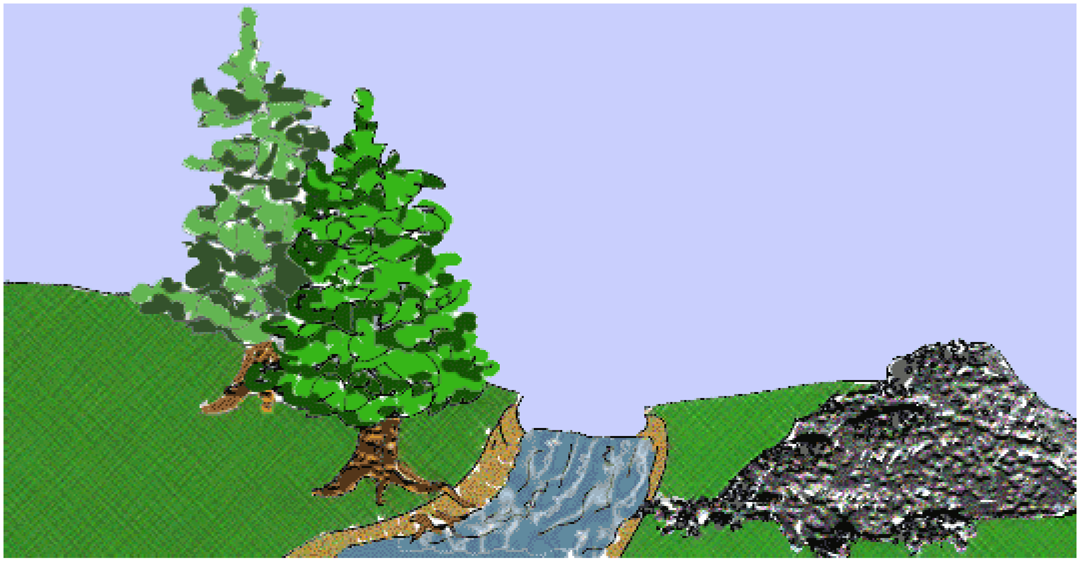
a. Temperature
b. Transparency
c. Conductivity
d. Acidity

6. New London Farms has opened a new vegetable farm along the Sawtooth River. Where would you test the water to see how the farm runoff affects the river? Draw a test site with an "X" on the map below. You may use as many test sties as necessary to obtain the most reliable results. Explain the purpose of any test site location.



7. Where would you expect dissolved oxygen to be highest: In the shallow water or deep water? Please explain your answer.

8. The map below shows a stream with some nearby trees and a gravel hill. Where would you expect runoff to cause higher alkalinity levels in the water?



a. near the old gravel hill
b. near the pine trees
c. near both the gravel hill and the pine trees
d. near neither the gravel hill nor the pine trees

Explain your answer.

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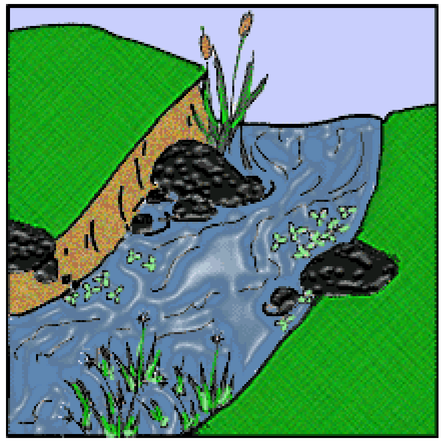
9. Look at the two pictures of a stream bed below.



Which two elements are most likely to differ between the two stream beds?

a. Nitrates and dissolved oxygen
b. Acidity and nitrates
c. Temperature and conductivity
d. Dissolved oxygen and temperature

10. For 5 days in a row, students collected water quality data from a lake near their school in the morning and at noon. Their measurements showed that the dissolved oxygen increased during the day (See table below). What conclusions would you draw from this finding? Explain your reasoning.

Dissolved oxygen levels

	Monday (mg/l)	Tuesday (mg/l)	Wednesday (mg/l)	Thursday (mg/l)	Friday (mg/l)
7 a.m.	4.0	3.5	4.0	3.7	3.9
noon	7.0	6.0	6.5	7.1	7.0

Section B: Crayfish Task (Inquiry in the Hydrology Investigation Area)

Instructions:

North Carolina is home to more than 45 species of crayfish. Many lived in local streams for 1 million years and are not found anywhere else in the world. Now some of these crayfish may be in danger of being wiped out because of changes in their environment.

For this task, imagine that the North Carolina State Museum of Natural Sciences has asked you to help study the health of the crayfish populations in streams throughout the state. The Museum wants you to find out what changes in water quality might be putting the crayfish in danger.

The Museum scientists would also like your class and others around the state to design a scientific study to identify which elements of water quality may put crayfish species at risk. The Museum would like you to:

1. Select sites to visit
2. Use data on water quality measures to identify aspects of water quality that affect the survival of crayfish.
3. Use data on water quality measures to select sites for the Museum to monitor that may be dangerous to crayfish.

1. What do you predict you might measure to help explain how water quality might be putting crayfish in danger?

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2. Yolanda thinks you need to just test crayfish species that are at-risk to see how water quality affects the health of crayfish. Jean thinks you need to test both healthy and at-risk crayfish species. Who is right and why?

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3. Once the test sites were selected, the Museum told the students across the state that they needed to record measurements of water quality once every two weeks during the entire school year. Some students thought this sounded like a lot of work.

Why would the museum want to collect data consistently over time?

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4. Two groups of students were measuring water temperatures in the Swannanoa River on a cold, windy day. One group got readings of about 6° C and one group got readings of about 3° C. What is a possible reason for the differences between the students' readings?

   a. Only one group calibrated their thermometer.
   b. One group delayed reading the thermometer.
   c. The wind might have interfered with the reading.
   d. All of the above

5. Sometimes it is difficult to interpret the colors on a pH strip. What usually causes this problem?

   a. The light in the area is not sufficiently bright
   b. The students did not calibrate the pH strips
   c. Low electrical conductivity in the water
   d. The river water is far too acidic

6. Students collecting data over several months in four different locations found the following dissolved oxygen data:

Crayfish Species	Condition	December (mg/l)	January (mg/l)	February (mg/l)	March (mg/l)
C reburrus	At risk	1.5	2	1.7	1.5
C spicatus	At risk	1.4	1.7	2.0	1.8
C hobbsorum	Stable	6.0	6.5	7.0	6.8
C bartonii	Stable	7.0	7.1	7.2	7.0

Use the chart above to figure out how dissolved oxygen levels in at-risk locations compare with dissolved oxygen levels in currently stable areas.

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7. What might you conclude from this chart about the relationship between dissolved oxygen levels and the health of these crayfish species?

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8. After a couple weeks of data collection, students across four counties discovered they each had the same species of crayfish, but the species was at different levels of risk in each location. They collected the following water temperature data over several months in each location:

Species	Condition	December (° C)*	January (° C)*	February (° C)*	March (° C)*
C latimanus	At risk	7°	5°	3°	5°
C latimanus	At risk	6°	3°	4°	4°
C latimanus	Stable	15°	12°	15°	18°
C latimanus	Stable	17°	18°	16°	16°

* mean average monthly water temperatures

9. How do water temperatures in at-risk locations compare with water temperatures in currently stable areas?

10. Based on these data, what is one conclusion you might make about the impact of water temperature variation in these streams on the health of crayfish populations?

11. Students studying the crayfish species, *Cambarus bartonii*, found the following differences in Secchi disk readings between a local creek and a creek in Virginia, where the species had died off in recent years:

Location	TRB Secchi December (cm)	TRB Secchi January (cm)	TRB Secchi February (cm)	TRB Secchi March (cm)
Virginia (at risk area)	1.0	.5	.5	.75
Graham County, NC (currently stable area)	8.0	9.0	9.5	1.0

What do these data indicate about the impact of particulate matter on crayfish survival?

12. The students gathered their water quality test measurements over the year and reviewed the trends. They found that dissolved oxygen changed over the spring months in different ways at the different testing sites. These data are in the table below. Please draw a graph that would best show how dissolved oxygen levels changed over time across all six sites.

Test Site	Mar (mg/l)	Apr (mg/l)	May (mg/l)
1	1.5	.5	.5
2	1.5	.5	.5
3	1.0	.5	.5
4	6.0	6.0	5.5
5	7.0	7.0	6.5
6	9.0	9.0	8.5

13. Please use your chart to write a paragraph report to the Curator of Crustaceans on the relationship between dissolved oxygen levels at each of the sites and the likely health of the crayfish species there. You can use your answers to questions you have already answered. Your paragraph must include each of the following:

    1. A statement about the relationship between dissolved oxygen and crayfish species health.
    2. A prediction as to which test sites (1-6) are likely to have crayfish species that are at risk.
    3. Your graph and an explanation of how your graph supports your prediction about which sites are at risk.

Dear Curator,

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GLOBE Student Survey

1. Name of class (e.g., Earth Science I): ________________________________

2. Your grade (circle one): 5 6 7 8 9 10 11 12

3. Your age (circle one): 10 11 12 13 14 15 16 17 18

4. Your Gender (circle one): Male Female

Please answer the following questions about your science class during this school year.

5. About how often do you take part in the following types of activities in the science class you're in right now or as part of GLOBE?	**Never**	**1-3 times this school year**	**1-3 times a month**	**1-3 times a Week**	**Almost Everyday**
a. Memorize basic facts and formulas that are in the textbook	❑	❑	❑	❑	❑
b. Learn science vocabulary	❑	❑	❑	❑	❑
c. Do hands-on/laboratory activities	❑	❑	❑	❑	❑
d. Work on projects that take a week or more	❑	❑	❑	❑	❑
e. Suggest or help plan classroom investigations	❑	❑	❑	❑	❑
f. Collect and record data	❑	❑	❑	❑	❑
g. Look at the same data displayed in different ways (for example, table and graph)	❑	❑	❑	❑	❑
h. Identify possible causes of differences in data (for example, mistakes made in measuring something)	❑	❑	❑	❑	❑
i. Identify patterns in data and come up with explanations for them	❑	❑	❑	❑	❑
j. Explain your thinking or reasoning about data you have collected	❑	❑	❑	❑	❑
k. Fill out lab reports	❑	❑	❑	❑	❑

6. About how often have you studied the following ideas about hydrology as part of this science class this year? Mark one box to the right of each concept listed below.	Not at all	1 to 2 class periods	More than 2 class periods
a. Water Transparency	❑	❑	❑
b. Water Temperature	❑	❑	❑
c. Dissolved Oxygen (DO)	❑	❑	❑
d. pH	❑	❑	❑
e. Electrical Conductivity	❑	❑	❑

7. How much time do you spend each week doing science homework or learning about science when you're not at school?	No time	1 hour or less	More than 1 hour
	❑	❑	❑

8. How often have you done each of the following GLOBE activities during this school year?	Never	1-3 times this school year	1-3 times a month	1-3 times a Week	Almost Everyday
a. Taken measurements using GLOBE protocols	❑	❑	❑	❑	❑
b. Used a computer to enter GLOBE data into the GLOBE Student Data Archive	❑	❑	❑	❑	❑
c. Talked about GLOBE data that you or other students collected	❑	❑	❑	❑	❑
d. Conducted an analysis or solved a problem using GLOBE data	❑	❑	❑	❑	❑
e. Answered a question that you chose using GLOBE data	❑	❑	❑	❑	❑
f. Participated in a GLOBE learning activity	❑	❑	❑	❑	❑

The following statements ask about your attitudes toward science and your ideas about what scientists do.

9. Please check the box that best shows how much you agree or disagree with each statement.	**Strongly agree**	**Agree**	**Disagree**	**Strongly disagree**
a. I am good at science	❑	❑	❑	❑
b. Doing scientific experiments is fun.	❑	❑	❑	❑
c. Studying for a science test often makes me nervous or upset	❑	❑	❑	❑
d. I often feel bad when I open my science book	❑	❑	❑	❑
e. I am interested in a career in science	❑	❑	❑	❑
f. It is important to know science	❑	❑	❑	❑
g. I like using technology (such as calculators and computers) in science	❑	❑	❑	❑
h. I am not interested in studying science in college	❑	❑	❑	❑
i. You have to have good luck to do well in science	❑	❑	❑	❑
j. You have to work hard studying to do well in science	❑	❑	❑	❑
k. You have to have natural talent or natural ability to do well in science	❑	❑	❑	❑
l. You have to memorize the textbook or your notes to do well in science	❑	❑	❑	❑
m. I like working on a team in science class	❑	❑	❑	❑
n. I like to think carefully by myself in science class	❑	❑	❑	❑

Thank you for participating in this GLOBE survey.

GLOBE Student Survey [For non-GLOBE students]

1. Name of class (e.g., Earth Science I): ______________________________

2. Your grade (circle one): 5 6 7 8 9 10 11 12

3. Your age (circle one): 10 11 12 13 14 15 16 17 18

4. Your Gender (circle one): Male Female

Please answer the following questions about your science class and GLOBE activities during this school year.

5. About how often do you take part in the following types of activities in the science class you're in right now?	**Never**	**1-3 times this school year**	**1-3 times a month**	**1-3 times a Week**	**Almost Everyday**
a. Memorize basic facts and formulas that are in the textbook	❏	❏	❏	❏	❏
b. Learn science vocabulary	❏	❏	❏	❏	❏
c. Do hands-on/laboratory activities	❏	❏	❏	❏	❏
d. Work on projects that take a week or more	❏	❏	❏	❏	❏
e. Suggest or help plan classroom investigations	❏	❏	❏	❏	❏
f. Collect and record data	❏	❏	❏	❏	❏
g. Look at the same data displayed in different ways (for example, table and graph)	❏	❏	❏	❏	❏
h. Identify possible causes of differences in data (for example, mistakes made in measuring something)	❏	❏	❏	❏	❏
i. Identify patterns in data and come up with explanations for them	❏	❏	❏	❏	❏
j. Explain your thinking or reasoning about data you have collected	❏	❏	❏	❏	❏
k. Fill out lab reports	❏	❏	❏	❏	❏

6. About how often have you studied the following ideas about hydrology as part of this science class this year? Mark one box to the right of each concept listed below.

	Not at all	1 to 2 class periods	More than 2 class periods
a. Water Transparency	❑	❑	❑
b. Water Temperature	❑	❑	❑
c. Dissolved Oxygen (DO)	❑	❑	❑
d. pH	❑	❑	❑
e. Electrical Conductivity	❑	❑	❑

7. How much time do you spend each week doing science homework or learning about science when you're not at school?

No time	1 hour or less	More than 1 hour
❑	❑	❑

The following statements ask about your attitudes toward science and your ideas about what scientists do.

8. Please check the box that best shows how much you agree or disagree with each statement.	**Strongly agree**	**Agree**	**Disagree**	**Strongly disagree**
a. I am good at science	❑	❑	❑	❑
b. Doing scientific experiments is fun.	❑	❑	❑	❑
c. Studying for a science test often makes me nervous or upset	❑	❑	❑	❑
d. I often feel bad when I open my science book	❑	❑	❑	❑
e. I am interested in a career in science	❑	❑	❑	❑
f. It is important to know science	❑	❑	❑	❑
g. I like using technology (such as calculators and computers) in science	❑	❑	❑	❑
h. I am not interested in studying science in college	❑	❑	❑	❑
i. You have to have good luck to do well in science	❑	❑	❑	❑
j. You have to work hard to do well in science	❑	❑	❑	❑
k. You have to have natural talent or natural ability to do well in science	❑	❑	❑	❑
l. You have to memorize the textbook or your notes to do well in science	❑	❑	❑	❑
m. I like working on a team in science class	❑	❑	❑	❑
n. I like to think carefully by myself in science class	❑	❑	❑	❑

Thank you for participating in this GLOBE survey.

GLOBE Teacher Survey

As part of the GLOBE Centennial study, your students have participated in an assessment of their knowledge of hydrology. Please answer the following questions about this class or students.

1. Name of class (e.g., Earth Science I): ______________________________

2. Total number of students in this class: ________

3. This class consists of (please select one):

- Mostly high-achieving students
- Mostly average-achieving students
- Mostly low-achieving students
- Students at a range of achievement levels

4. How frequently did students in this class take part in the following types of activities, as part of your curriculum for the Hydrology unit? (Check one for each activity.)	Never	1-3 times this school year	1-3 times a month	1-3 times a Week	Almost Everyday
a. Memorize basic facts and formulas that are in the textbook	●	●	●	●	●
b. Learn science vocabulary	●	●	●	●	●
c. Do hands-on/laboratory activities	●	●	●	●	●
d. Work on projects that take a week or more	●	●	●	●	●
e. Suggest or help plan classroom investigations	●	●	●	●	●
f. Collect and record data	●	●	●	●	●
g. Look at the same data displayed in different ways (for example, table and graph)	●	●	●	●	●
h. Identify possible causes of differences in data (for example, mistakes made in measuring something)	●	●	●	●	●
i. Identify patterns in data and come up with explanations for them	●	●	●	●	●
j. Explain your thinking or reasoning about data you have collected	●	●	●	●	●
k. Fill out lab reports	●	●	●	●	●

5. How often have students in this class studied the following *hydrology* concepts in this school year? (Check one for each concept.)	**Not at all**	**1 to 2 class periods**	**More than 2 class periods**
a. Water quality or composition	●	●	●
b. Water temperature	●	●	●
c. Water chemistry	●	●	●
d. pH	●	●	●
e. Water polarity	●	●	●

Questions 6 and 7 ask about your classroom's implementation of protocols and learning activities in the Hydrology Investigation Area of GLOBE.

6. Which of the following *Hydrology Protocols* have you implemented with your class this school year? (Check the frequency for each protocol implemented.)	**Once**	**2 or 3 times**	**More than 3 times**
a. Transparency	●	●	●
b. Water Temperature	●	●	●
c. Dissolved Oxygen (DO)	●	●	●
d. pH	●	●	●
e. Electrical Conductivity	●	●	●
f. Salinity	●	●	●
g. Alkalinity	●	●	●
h. Nitrate	●	●	●
i. Fresh Water or Marine Macroinvertebrates	●	●	●

7. Which of the following GLOBE Hydrology Learning Activities have you implemented with your class this school year? (Check the frequency for each learning activity implemented.)	Once	2 or 3 times	More than 3 times
a. Water Walk Mapping and profiling Hydrology Study Site to raise questions about local land use/and or water chemistry	●	●	●
b. Model Your Watershed Using maps and Landsat images to model watersheds and water flow	●	●	●
c. Water Detectives Identifying substances in water	●	●	●
d. The pH Game Measuring pH from water, soil, and plant material	●	●	●
e. Practicing the Protocols Testing students' skill in taking measurements and exploring variation and error	●	●	●
f. Water, Water Everywhere! Exploring and analyzing GLOBE Hydrology data	●	●	●
g. Macroinvertebrate Discovery Sorting and counting organisms from Hydrology site and investigating relationships with water chemistry	●	●	●
h. Modeling Your Water Balance Modeling the change in soil water storage over a year's time and comparing the model with GLOBE soil water content and biometry data	●	●	●

Questions 8 to 11 ask about your GLOBE program implementation.

8. How frequently this school year have students in this class done each of the following GLOBE activities?	Not at all	Once	More than once but less than once a month	Average of 1-3 times a month	Average of once a week or more
a. Take measurement using GLOBE protocols	●	●	●	●	●
b. Entered GLOBE data into the GLOBE Student Data Archive	●	●	●	●	●
c. Talked about GLOBE data they or other students collected	●	●	●	●	●
d. Conducted an analysis or solved a problem using GLOBE data	●	●	●	●	●
e. Answered a question of their own choosing using GLOBE data	●	●	●	●	●
f. Participated in a GLOBE learning activity	●	●	●	●	●

9. Where do students usually use computers for GLOBE-related activities, and how many computers are available in each room? (Check all that apply and enter number of computers.)

	Number of computers
● 1.Classroom	____________________
● 2. Computer lab	____________________
● 3. Media center	____________________
● 4. Other	Please specify other: ____________________

10. What are the goals for your students' achievement that motivate you to implement GLOBE activities? (Check one for each effect.)	**Not a goal**	**Minor goal**	**Major goal**
a. Knowledge of science curriculum	●	●	●
b. Development of knowledge/skill in other curricular areas (e.g., math, reading)	●	●	●
c. Practice with scientific process	●	●	●
d. Development of technology skills	●	●	●
e. Development of personal standards (responsibility, commitment, accuracy)	●	●	●
f. Development of interpersonal skills (communication, teamwork, leadership)	●	●	●
g. Increase in awareness of environment	●	●	●
h. Opportunity to interact with groups external to the school (i.e., students at other schools, GLOBE scientists)	●	●	●
i. Opportunity to contribute to scientists' knowledge about the environment	●	●	●

11. How congruent with GLOBE are the standards for science learning that you must address? (Check one box for each level of standards.)	**Not very congruent**	**Moderately congruent**	**Very congruent**
a. Standards within your school	●	●	●
b. Standards within your school district	●	●	●
a. Standards within your state	●	●	●

Questions 12 and 13 ask you to reflect on your experience of the GLOBE teacher training course.

12. Think about the GLOBE training you received and check the box which best shows how much you agree or disagree with each statement.

The training prepared me to:	Strongly disagree	Moderately disagree	Neutral	Moderately agree	Strongly agree
a. implement GLOBE protocols with my students.	●	●	●	●	●
b. implement GLOBE learning activities with my students.	●	●	●	●	●
c. adapt GLOBE to the ability levels and learning styles of my students.	●	●	●	●	●
d. adapt GLOBE to the science standards in my school/district/state.	●	●	●	●	●

13. Have you benefited from teacher support offered by the organization that provided your training? (Check the frequency for each support you used.)

	Never	Infrequently	Frequently
a. Participation incentives (e.g., equipment, recognition for reporting specific amounts of data)	●	●	●
b. Communications (newsletter, listserv, email or telephone contact, meetings and conferences)	●	●	●
c. Supplementary materials (e.g., tips for GLOBE implementation)	●	●	●
d. Follow-up or refresher training session	●	●	●
e. On-site mentoring by GLOBE partner staff or experienced GLOBE teachers	●	●	●

14. If you have further comments, please use the space below.

Thank you for participating in this GLOBE survey.

GLOBE Teacher Survey (for Non GLOBE Teacher)

As part of the GLOBE Centennial study, your students have participated in an assessment of students' knowledge of hydrology. Please answer the following questions about this class or students.

1. Name of class (e.g., Earth Science I): ______________________________

2. Total number of students in this class: ________

3. This class consists of (please select one):

- Mostly high-achieving students
- Mostly average-achieving students
- Mostly low-achieving students
- Students at a range of achievement levels

4. How frequently did students in this class take part in the following types of activities, as part of your curriculum for the Hydrology unit? (Check one for each activity.)	Never	1-3 times this school year	1-3 times a month	1-3 times a Week	Almost Everyday
a. Memorize basic facts and formulas that are in the textbook	●	●	●	●	●
b. Learn science vocabulary	●	●	●	●	●
c. Do hands-on/laboratory activities	●	●	●	●	●
d. Work on projects that take a week or more	●	●	●	●	●
e. Suggest or help plan classroom investigations	●	●	●	●	●
f. Collect and record data	●	●	●	●	●
g. Look at the same data displayed in different ways (for example, table and graph)	●	●	●	●	●
h. Identify possible causes of differences in data (for example, mistakes made in measuring something)	●	●	●	●	●
i. Identify patterns in data and come up with explanations for them	●	●	●	●	●
j. Explain your thinking or reasoning about data you have collected	●	●	●	●	●
k. Fill out lab reports	●	●	●	●	●

5. How often have students in this class studied the following *hydrology* concepts in this school year? (Check one for each concept.)	Not at all	1 to 2 class periods	More than 2 class periods
a. Water quality or composition	●	●	●
b. Water temperature	●	●	●
c. Water chemistry	●	●	●
d. pH	●	●	●
e. Water polarity	●	●	●

Questions 6 and 7 ask about your plan for implementing GLOBE protocols and learning activities in the Hydrology Investigation Area for the rest of this school year.

6. Which of the following *Hydrology Protocols* do you plan to implement with your class in the rest of this school year? (Check the frequency for each protocol implemented.)	Once	2 or 3 times	More than 3 times
a. Transparency	●	●	●
b. Water Temperature	●	●	●
c. Dissolved Oxygen (DO)	●	●	●
d. pH	●	●	●
e. Electrical Conductivity	●	●	●
f. Salinity	●	●	●
g. Alkalinity	●	●	●
h. Nitrate	●	●	●
i. Fresh Water or Marine Macroinvertebrates	●	●	●

7. Which of the following GLOBE Hydrology Learning Activities do you plan to implement with your class in the rest of this school year? (Check the frequency for each learning activity implemented.)	Once	2 or 3 times	More than 3 times
a. Water Walk Mapping and profiling Hydrology Study Site to raise questions about local land use/and or water chemistry	●	●	●
b. Model Your Watershed Using maps and Landsat images to model watersheds and water flow	●	●	●
c. Water Detectives Identifying substances in water	●	●	●
d. The pH Game Measuring pH from water, soil, and plant material	●	●	●
e. Practicing the Protocols Testing students' skill in taking measurements and exploring variation and error	●	●	●
f. Water, Water Everywhere! Exploring and analyzing GLOBE Hydrology data	●	●	●
g. Macroinvertebrate Discovery Sorting and counting organisms from Hydrology site and investigating relationships with water chemistry	●	●	●
f. Modeling Your Water Balance Modeling the change in soil water storage over a year's time and comparing the model with GLOBE soil water content and biometry data	●	●	●

Questions 8 and 9 ask you about your goals for your students in relation to GLOBE, as well as your judgment about GLOBE's alignment to the standards.

8. What are the goals for your students' achievement that would motivate you to implement GLOBE activities?	Not a goal	Minor goal	Major goal
a. Knowledge of science curriculum	●	●	●
b. Development of knowledge/skill in other curricular areas (e.g., math, reading)	●	●	●
c. Practice with scientific process	●	●	●
d. Development of technology skills	●	●	●
e. Development of personal standards (responsibility, commitment, accuracy)	●	●	●
f. Development of interpersonal skills (communication, teamwork, leadership)	●	●	●
g. Increase in awareness of environment	●	●	●
h. Opportunity to interact with groups external to the school (i.e., students at other schools, GLOBE scientists)	●	●	●
i. Opportunity to contribute to scientists' knowledge about the environment	●	●	●

9. How congruent with GLOBE are the standards for science learning that you must address? (Check one box for each level of standards.)	Not very congruent	Moderately congruent	Very congruent
a. Standards within your school	●	●	●
b. Standards within your school district	●	●	●
a. Standards within your state	●	●	●

Questions 10 and 12 ask you to reflect on your experience of the GLOBE teacher training course.

10. Think about the GLOBE training you received and check the box which best shows how much you agree or disagree with each statement.

The training prepared me to:	Strongly disagree	Moderately disagree	Neutral	Moderately agree	Strongly agree
a. implement GLOBE protocols with my students.	●	●	●	●	●
b. implement GLOBE learning activities with my students.	●	●	●	●	●
c. adapt GLOBE to the ability levels and learning styles of my students.	●	●	●	●	●
d. adapt GLOBE to the science standards in my school/district/state.	●	●	●	●	●

11. Have you benefited from teacher support offered by the organization that provided your training? (Check the frequency for each support you used.)

	Never	Infrequently	Frequently
a. Participation incentives (e.g., equipment, recognition for reporting specific amounts of data)	●	●	●
b. Communications (newsletter, listserv, email or telephone contact, meetings and conferences)	●	●	●
c. Supplementary materials (e.g., tips for GLOBE implementation)	●	●	●
d. Follow-up or refresher training session	●	●	●
e. On-site mentoring by GLOBE partner staff or experienced GLOBE teachers	●	●	●

12. If you have further comments, please use the space below.

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Thank you for participating in this GLOBE survey.