# GLOBE YEAR 2 EVALUATION

## Implementation and Progress

December 1997

Prepared for:

Global Learning and Observations to Benefit the Environment (GLOBE)
744 Jackson Place
Washington, D.C.  20503

The Year 2 evaluation of the GLOBE Program was conducted by the Center for Technology in Learning of SRI International under Grant # ESI-9509718 with the National Science Foundation. The views expressed are those of the authors and do not necessarily reflect policies either of the NSF or of the GLOBE program.

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Prepared by:


Barbara Means
Elaine Coleman
Amy Lewis
Edys Quellmalz
Camille Marder
Kathryn Valdes


SRI Project 6992


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SRI International ◆ 333 Ravenswood Avenue ◆ Menlo Park, CA 94025-3493 ◆ (650) 362-6200

# Executive Summary

Global Learning and Observations to Benefit the Environment (GLOBE) is an international environmental science and education program involving elementary and secondary school students in collecting data concerning their local environments and in sharing that data through the Internet. Students and teachers are implementing 20 data collection protocols, designed by environmental scientists, as part of ongoing investigations in the areas of Atmosphere, Hydrology, Land Cover/Biology, Soil, and Global Positioning Systems (GPS). In addition, learning activities have been developed for each investigation area to put the data collection activities into an educationally meaningful context.

Other than requiring careful adherence to the data collection protocols, GLOBE gives schools complete latitude in determining the (K-12) grade levels and classes in which to implement the program, the educational activities to provide, and the way in which the program will fit into the local curriculum.

GLOBE teacher training sessions began in March 1995, and by August 1997, roughly 4,000 U.S. teachers and another 1,000 teachers internationally had received GLOBE training. During the 1996-97 school year, over 800 schools reported GLOBE data in a typical month.

The GLOBE program evolved considerably between the first and second school years of implementation, with:

- New, greatly expanded Teacher's Guide ("GLOBE II").
- Much better balance between educational content and data interpretation and analysis on the one hand and the collection of data on the other.
- Emphasis on training more than one teacher within a GLOBE school.
- Wider range of technology tools to support analytic and reflective activities as well as communication.
- Greater interaction between GLOBE scientists and GLOBE teachers.

Although the pace of change has left nearly all program participants with the sense that they are constantly straining to "catch up" with the latest developments, few doubt that the effort has been worth it. GLOBE's attempt to combine science, education, and technology on an unprecedented international scale has gone beyond the vision stage, to become a fact of life in hundreds of classrooms around the world.

## The Evaluation

SRI International was selected through a competitive grant process to provide GLOBE's evaluation component. This report summarizes evaluation activities and findings from 1996-97, the second school year of GLOBE implementation. (Year 1 evaluation findings were documented in an earlier report, Means et al., 1996.)

One component of the Year 2 evaluation was a teacher survey administered in the spring of 1997 to those teachers whose schools had been active contributors of GLOBE data between September 1996 and March 1997. The survey addressed implementation issues, including the settings and age groups with which GLOBE was being implemented, challenges involved in carrying out the program, and implementation rates for the protocols and learning activities in the revised Teacher's Guide, as well as teachers' perceptions of GLOBE's effects on students. Of the 441 teachers who received surveys, 344 returned completed forms, for a response rate of 78%.

A comparative substudy, also conducted in the spring of 1997, contrasted the pedagogy and curriculum as well as student performance in 44 classes of active GLOBE teachers working with students at the 4th-, 7th-, or 10th-grade level, compared with 27 classes at the same grade levels taught by teachers who had signed up for GLOBE training but not yet implemented the program with their students. Teachers in the comparative substudy were asked about the characteristics of their school, the size of their single most active GLOBE class or club (or of the class most similar to that within which they planned to introduce GLOBE), and their classroom coverage of a range of Earth science topics.

Students in the comparative substudy received surveys containing an embedded assessment. Surveys for both GLOBE and non-GLOBE students contained questions about the kinds of activities typically performed during their science class, their attitude toward the study of science and Earth systems, and their concepts of how practicing scientists spend their time. In addition, GLOBE students were asked about the appeal of various GLOBE activities.

The assessment portion of the surveys was the same for GLOBE and non-GLOBE students. Items for the 1997 assessment were chosen from an item bank, which was started in 1996 and added to during the second year of the evaluation. In developing assessment items for this bank, SRI took care to construct items that tested more than factual information. Typically, the items provide a context including an illustration or set of data with one or more questions addressing this problem context. Some of the items are modifications of items used on earlier state, national, or international assessments.

SRI developed a framework for developing items keyed to the GLOBE investigation areas and to three kinds of learning that could reasonably be expected to be promoted by GLOBE. The first item type concerned the ability to take accurate measurements of variables included in the GLOBE protocols. The second area concerned general principles of sampling and measurement, including steps to increase the accuracy of an estimate, handling of inconsistent data, and so on. The third area was the ability to interpret data, presented in graphs, tables, or narrative form, and to apply Earth science concepts to new contexts. Surveys were received from 1,453 students in the 44 GLOBE classes and 27 non-GLOBE classes.

The evaluation team also conducted site visits to five U.S. sites representing a range of implementation models and grade levels. These visits, conducted between March and May 1997, incorporated interviews with GLOBE teachers, observations of GLOBE activities, informal discussions with students, and interviews with administrators.

## The Findings

On our survey of GLOBE teachers whose schools had submitted 75 or more data reports including three or more data categories between September 1996 and March 1997, all teachers reported that students at their school take GLOBE measurements during a typical week. Ninety-nine percent of the 344 teachers in our survey sample reported having students entering GLOBE data on a computer during a typical week; 87% having students examine information on the GLOBE Web site; 85% doing GLOBE learning activities; 86% analyzing and discussing GLOBE data; and 63% using GLOBEMail to communicate with another GLOBE school.

Implementation rates for specific GLOBE protocols vary widely. Each of the GLOBE data collection protocols in the Atmosphere investigation was implemented by 75% or more of the active schools in our survey sample. Reported implementation rates for the Hydrology protocols that were carryovers from GLOBE I and for establishing the study site and using the GPS were over 65%. Smaller proportions of teachers implemented the other GLOBE II protocols during 1996-97, with seven protocols used by fewer than 15% of the active GLOBE teachers. Implementation rates for new protocols were particularly low at the elementary school level.

Students in active GLOBE classes have a very positive view of the importance of their GLOBE activities: 83% said that they think the GLOBE project will help people better understand the Earth and 78% that their measurements are important for scientists. Only 14% said that they do not know why they take the measurements they do.

Among 4th-graders, entering GLOBE data on the computer is the most popular program activity (with 76% saying they like doing this “a lot”), followed by taking measurements (69% like “a lot”) and examining satellite pictures (63%). Among 7th- and 10th-graders, on the other hand, looking at satellite images is the most popular GLOBE component (56% reported liking it “a lot”).

Comparisons between GLOBE and non-GLOBE students in terms of typical activities performed during science class are revealing. Compared with non-GLOBE students, GLOBE students reported spending more time using a computer, working in a group with other students, and helping other students learn. Students in non-GLOBE science classes reported spending more time learning new words, answering questions from a book or worksheet, and answering questions about what they have learned.

These reports parallel those of the students’ teachers. Compared with teachers who want to implement GLOBE but have not yet taken the training or started the program, GLOBE teachers spend less science instruction time teaching vocabulary or having students complete worksheets. They spend more time having students *do* science: taking measurements or observations, applying science concepts, and analyzing and interpreting data. Moreover, students exposed to GLOBE performed better than their age-mates in comparison classes on assessments, not only of their ability to take the kinds of measurements used in GLOBE but also in terms of their knowledge of sampling and measurement principles and their ability to interpret data and apply science concepts. When GLOBE and non-GLOBE students’ performances in Earth science content areas in which they both received some instruction were compared, GLOBE students outperformed non-GLOBE students by 53% versus 36% for knowledge of measurement procedures, 56% versus 51% for sampling and measurement principles, and 48% versus 42% for interpreting data and applying concepts. GLOBE students also have a fuller appreciation of what it means to be a scientist and are more interested in pursuing a career in science (34% vs. 25%).

In the minds of active GLOBE teachers, the biggest impacts of the program on student learning are in the areas of observational skills (69% of teachers actively providing data reported that GLOBE has improved skills "very much"), measurement skills (68% "very much"), and technology skills (60%). Roughly half of these teachers think GLOBE has very much improved students' abilities to understand data and to work in small groups. Smaller but still significant proportions reported major improvements in critical thinking (36%) and map skills (30%). Among the various investigation areas, the largest increase in student knowledge, in teachers' view, is in the area of atmosphere and climate, with 74% of active teachers reporting that their students' knowledge has increased "very much."

The active GLOBE teachers reported that the biggest challenge they face in implementing the program is obtaining measurements during weekends and vacations. A variety of time pressures constitute the next most difficult issues: completing GLOBE activities within the confines of the school schedule of brief blocks of instruction; finding a place for GLOBE, given other curricular and testing demands; and finding enough of their own time to conduct the preparation and support work needed for implementing GLOBE. These major challenges were identical to those cited by active teachers in an earlier survey (administered in spring 1996 as part of the Year 1 evaluation). The only challenge that appeared to diminish in perceived magnitude between the two surveys is problems with logging on to the GLOBE server. Hence, there is no evidence that GLOBE implementation has become easier over time. It should be remembered, however, that a very large body of new content was added to the program in November 1996. Because of these additions, GLOBE teachers were coping with new demands rather than just replicating activities conducted the previous year.

## Emerging Issues

The second-year evaluation highlighted some issues for GLOBE to consider as it continues to evolve and refine its support structure.

***Increasing the proportion of GLOBE-trained teachers who fully implement the program.*** Although students may be benefiting from GLOBE content in schools that are not reporting data, such implementations fall short of the original GLOBE concept and do not contribute toward the GLOBE goal of increasing scientific knowledge about Earth systems.

***Supporting implementation at a variety of grade levels and in varying contexts.*** Both primary grade teachers and teachers at the upper grades express some concerns about the match between GLOBE and their students' level or their required curriculum.

***Providing in-depth preparation, supports, and incentives for teachers to implement a range of protocols and learning activities***. The current set of protocols and activities is so large as to be overwhelming to many teachers, who choose to limit their participation to the Atmosphere investigation. If teachers (or teacher teams) can be incentivized to participate in multiple GLOBE investigation areas, students will have a better opportunity to gain an appreciation of the interdependence of Earth systems.

***Supporting teachers in training their colleagues to implement GLOBE***. As schools move toward having multiple teachers implementing GLOBE, the initial GLOBE-trained teachers themselves become de facto GLOBE trainers within their schools. To date, the GLOBE program has done relatively little to address the needs of these "unofficial" GLOBE trainers, other than making the GLOBE trainers' slides available on the World Wide Web. GLOBE hopes that local training franchises will increase the likelihood that additional teachers at GLOBE schools receive formal GLOBE training. In addition, the program is considering developing Web-based GLOBE training and is in the process of letting a contract for the development of GLOBE training videos.

***Sustaining school interest and involvement over time.*** Teacher turnover, competing demands, and changes in schedules can disrupt a school's GLOBE program. But to the extent that there is greater commitment to the program on the part of the school and that the commitment extends beyond a single GLOBE teacher, greater program continuity can be expected. The GLOBE program is taking steps to encourage a multi-teacher "community of learners" implementation approach and to provide more interest-sustaining events such as Web chats, a teacher conference (held in Boulder, Colorado, in July 1997), an international student and teacher conference (to be held in Helsinki, Finland, in June 1998), and special projects such as the El Niño investigation.

***Increasing support for classroom assessments.*** The revised GLOBE Teacher's Guide contains sections on assessment for each investigation area, but these sections are often only loosely specified and are nearly always incomplete in that they lack specifications for evaluating students' work. GLOBE is in the process of letting a grant to support the development of a much more fully worked out set of assessment materials for classroom use.

***Monitoring program quality as more training is provided by "third parties."*** As more teachers learn how to implement GLOBE, either from colleagues at their schools or from GLOBE "franchises," questions about quality control become more pressing. The program is getting to a stage where it will soon be possible to develop indices of program quality (such as number of students and teachers involved, adequacy of data set contributed) and to start examining the relationship between the type of training teachers have received and the quality of the GLOBE program they implement. Such analyses may show variants of the conventional GLOBE training model that are significantly less or significantly more effective. In either case, implications can be drawn which will inform further refinement of the GLOBE program.

## Conclusion

The GLOBE program continues to be characterized by the strong teacher and student enthusiasm demonstrated in its first year, by its adaptability to a wide range of grade levels and contexts, and by its compatibility with inquiry and collaborative learning models. It is an excellent example of substantive educational use of the Internet and is highly compatible with national science and mathematics standards. Data from our research comparing GLOBE and non-GLOBE classrooms provide evidence to support the conclusion that participation in GLOBE increases the likelihood that teachers will have their students engage in *doing* aspects of science (such as making measurements or observations, applying concepts, and interpreting data) rather than confining their instruction to giving definitions of terms and concepts. Further, there is evidence that involvement in GLOBE activities increases not just students' ability to take the environmental measurements included in the program but also their ability to apply more broadly principles of sound sampling and data collection and to interpret data. Taken as a whole, the assessment data are very encouraging. After GLOBE's second year of operation, there is evidence of enhanced science and mathematics learning in classrooms where GLOBE is being implemented. Just as important, the program is giving students a new perspective on what it means to do science and to be part of a scientific investigation. GLOBE's combination of hands-on activity, technology use, and involvement in real research projects provides students with a deep sense of the value of their activities.

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## EXHIBITS

# Chapter 1. Introduction

Students, teachers, and scientists are collaborating worldwide in Global Learning and Observations to Benefit the Environment (GLOBE). K-12 classrooms in dozens of countries are collecting data on their local environment and sharing that data with each other and with the scientific community through the World Wide Web. GLOBE views the Earth as a dynamic system, with special attention to mapping and understanding patterns in the areas of atmosphere/climate, hydrology/water chemistry, and land cover/biology.

Vice President Al Gore articulated the GLOBE program concept and invited the participation of countries from around the world on Earth Day, 1994. An interagency team, brought together from the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), the Environmental Protection Agency (EPA), and the Departments of Education and State, was set up to staff the program. NOAA and NASA also provided teams of programmers to develop the software for collecting and managing the GLOBE data and for generating visualizations from the student data.

Distinctive features of the GLOBE program include its:

- *Focus*— on the global environment as a dynamic system.
- *Mission*—to improve math and science achievement, raise environmental awareness, and contribute to the scientific database on a global scale.
- *Use of technology*—low-cost measurement tools coupled with a higher-tech (World Wide Web-based) approach to data reporting and archiving.
- *Authenticity*—with scientists as well as students using GLOBE data.
- *Scope*—two years after the program's official launch on Earth Day 1995, 3,500 schools in 50 countries had signed on to participate.
- *Collaborative nature*—involving students, teachers, and scientists; interagency project planning and staffing; and a multinational data collection effort by K-12 schools.

## The Early Days

In November 1994, an invitation was issued for U.S. schools to join the GLOBE program. Schools applying to join GLOBE had to commit to sending a teacher to be trained, purchasing the GLOBE measurement equipment (if they did not already have it), following the schedule of data collection (which included weekends and school vacations), and participating for at least a 3-year period. Requirements for participation of U.S. schools also included an Internet connection and a computer capable of running a Web browser and the data visualization software. (A limited number of equipment grants were available for schools without the resources to purchase the needed equipment during the program's first year.)

In March 1995, the 400-page first edition of the GLOBE Teacher's Guide, based on protocols and activities used in previous environmental education programs, was ready, and training of teachers commenced and continued throughout the year. The training model adopted initially in the United States called for the involvement of one teacher from each GLOBE school. The 3-day training sessions, hosted by Space Grant programs at roughly a dozen university sites across the country, were conducted by teams composed of a facilitator, two scientists, one technology specialist, and two educators (by the summer of 1995, GLOBE teachers trained earlier were able to fill this role).

Although some teachers began collecting data immediately after the April (Earth Day) 1995 program launch, the first full school year of GLOBE implementation started in September 1995. The Year 1 Evaluation Report (Means et al., 1996) described the experiences of that first year in some detail.

Internationally, GLOBE provides the program infrastructure, and international partners manage their own implementation, acquiring the resources necessary to equip their own schools. Each country selects its own coordinator, decides how many and which schools to sponsor, and determines how GLOBE will be implemented in its schools. The only requirement is that participating schools conduct the measurements and report the data in accordance with the GLOBE data collection protocols, under the supervision of GLOBE-trained educators.

International workshops for country coordinators were held in four locations around the world during the summer and fall of 1995. The country coordinators then set up and conducted their own teacher training programs.

## Preparations for GLOBE II

During the spring of 1995, as the GLOBE program was beginning its first year of training using the initial set of data collection protocols and first edition of the Teacher's Guide, it also was laying the groundwork for its expanded second phase, involving larger numbers of scientific investigations, original educational activities, and curriculum integration and evaluation activities. In November 1994, the National Science Foundation invited applications from teams of Earth scientists and educators interested in shaping the GLOBE Phase II investigations. Teams were formed to design scientific investigations in the areas of atmosphere/climate, trace gases, water chemistry (e.g., water temperature, pH, and oxygen content), hydrology (e.g., water cycle), soils, and land cover/biology, and in the use of global positioning systems (GPS). Each team was to be headed up by a scientist principal investigator (PI) committed to using GLOBE data in his or her research and to collaborating with an education co-PI who would help develop educational activities that would put the data collection into a meaningful context. After selection of the grantees, work on the Phase II materials began in May 1995 and continued through July of the next year, when the first draft of the substantially rewritten second edition of the Teacher's Guide became available for training teachers in the summer of 1996. This edition included 30 learning activities designed to support the GLOBE II data collection protocols plus 6 activities related to an integrating investigation called Seasons. The second edition of the Teacher's Guide was mailed to previously trained GLOBE teachers in November 1997. Table 1.1 shows the GLOBE II data collection protocols in the second guide alongside those from the initial guide (GLOBE I).

### Program Refinements

Experience gained in GLOBE's first full academic year of operation (1995-96) and findings from the Year 1 evaluation (Means et al., 1996) were used in setting an agenda for program refinements during the second year. Targets for improvement identified during the first year included:

- Ongoing support for GLOBE teachers to help them cope with the many challenges in implementing GLOBE.
- Strategies and materials for placing GLOBE data collection in a meaningful context.
- Stimulation of greater use of underused protocols and technology tools.
- Provision of material appropriate for primary grades (K-3).

Program refinements undertaken to address these concerns are described below.

**Table 1.1**

**Comparison of GLOBE I and GLOBE II Data Collection Protocols**

| ***GLOBE I Protocols*** | ***GLOBE II Protocols**** |
|---|---|
| *Atmosphere Investigation* | |
| Air Temperature | Min/Max/Current Temperature |
| Precipitation (liquid & solid) | Rainfall |
| | Solid Precipitation |
| Cloud Cover | Cloud Cover |
| Cloud Type | Cloud Type |
| *Hydrology Investigation* | |
| Water Temperature | Water Temperature |
| Water pH | Water pH |
| | Dissolved Oxygen |
| | Alkalinity |
| | Electrical Conductivity |
| *Land Cover/Biology Investigation* | |
| Land Cover | Land Cover Mapping |
| Species Identification | Species Identification |
| Biometry | Biometry |
| Phenology | |
| | Establish Study Sites** |
| | Qualitative Validation Data Collection |
| | Quantitative Validation Data Collection |
| | Accuracy Assessment |
| Remote Sensing | |
| *Soils Investigation* | |
| Soil Moisture | Soil Moisture*** |
| | Soil Characterization |
| *GPS Investigation* | |
| GPS | GPS |

* Protocols in 1996 edition of Teacher's Guide. Additional GLOBE II protocols were added in 1997, after construction of the surveys on which this report is based.
** Included but not treated as a protocol in GLOBE I.
*** Although the protocol title is the same, an entirely different method is used in GLOBE II.

## Need for More Teacher Support

Teachers new to GLOBE face a formidable task. There are an extensive number of protocols to learn, equipment and technology to obtain, software and Web resources to master, and issues of scheduling, logistics, and curriculum integration to deal with.

During the first year, GLOBE offered equipment grants to a limited number of schools without the resources to purchase equipment, as well as access to a Help Desk for all participants. Although helpful, these supports were not enough for all teachers. Some GLOBE teachers expressed frustration with the obstacles they faced, and many talked about a need for ongoing communication with other GLOBE teachers and feedback from GLOBE scientists.

A number of efforts were launched during the second year to try to address such concerns. For purposes of exposition, we have divided these efforts into three basic categories: developing GLOBE "franchises," implementing a "community of learners" strategy, and the use of technology to support communication and a sense of community.

### Franchise Training Concept

GLOBE's strategy for growing the program within the U.S. has evolved from one of teacher recruitment and training managed directly by GLOBE staff to a "franchise" model. The franchise concept is a generic joint agreement between NOAA (representing GLOBE) and entities such as universities, school systems, consortia, or entire states that want to recruit, train, and mentor GLOBE teachers within their area. After a franchise agreement is negotiated, GLOBE trains the franchisee's trainers and makes sure that the necessary science, education, and systems support infrastructures are in place. The franchises stimulate local and regional interest in GLOBE and make it possible for the program to grow within the U.S. without increasing the level of federal investment. By August 1997, 36 franchise agreements had been negotiated. Because franchises are typically dealing with teachers in a local area, they have the potential to have more extensive follow-up contact with the teachers they train.

### Community of Learners Strategy

Ann Brown, a Harvard psychologist, has implemented what she calls a "community of learners" in several schools. The "community" involves multiple adults and students in working together to build their collective knowledge about areas of study. Collaboratively, the group, with its variety of expertise, engagement, and goals, is able to sustain a more complex inquiry than any one member could accomplish single-handed (Brown & Campione, 1987, p. 17). Energy and motivation are intensified when working in collaboration with peers.

The growing set of GLOBE data collection protocols and activities and the formidable set of technical and logistical issues that must be solved to fully implement the program prompted the realization that a full-fledged program could be better implemented by a team of teachers rather than a single teacher acting alone. Multiple teachers can "share the load" in terms of logistics and data collection responsibilities and insert GLOBE activities into multiple classrooms, as they fit with the particular learning goals for those groups of students. With multiple teachers and classrooms participating, one would expect to find a higher probability of getting a rich, continuous data set for the study site and of giving students a broad, multi-year exposure to GLOBE activities.

In addition, the participation of multiple teachers within a school makes a GLOBE program less susceptible to abandonment caused by teacher turnover. With nearly 13% of teachers leaving their schools (for other schools or leaving the profession altogether) each year (National Center for Education Statistics, 1997) any program that depends entirely on a single teacher is highly vulnerable.

Several steps were taken during GLOBE's second year to foster a move toward the involvement of multiple teachers within a school, or across schools, as well as partnering with community members to jointly implement GLOBE. Schools that asked to send second or third teachers to GLOBE training were encouraged to do so. The training itself was modified to include discussion of the community of learners concept and, at some training sessions, time was devoted to developing a specific implementation plan for spreading GLOBE throughout each teacher's school. (Examples of multi-teacher involvement within schools, taken from our site visits, are included in Chapter 5.) Because of their local or regional character, GLOBE franchises are in a good position to support communities of learners.

### Technology-Based Supports for Teachers

In the Year 1 evaluation, we found that GLOBE teachers want to sustain the sense of community developed during their week of GLOBE training and to have access to informal advice and support as they grapple with the challenges posed by setting up the equipment, technology, and learning and data collection activities of GLOBE. A teacher listserv was initiated for exclusive use by the GLOBE teachers. In addition, a section of the GLOBE Web site was devoted to teacher-recommended Internet resources and examples of GLOBE teacher and student work. In the spring of 1997, this “Resource Room” contained hot links to Internet sites plus five activity descriptions (“Classroom Suggestions”) developed by GLOBE teachers and students.

The Resource Room is an important part of the GLOBE Web site, not just because it contains model educational activities using the GLOBE data but also because it is a step toward making the Web site a forum where teacher accomplishments and perspectives are shared.

### Providing Meaningful Context for Data Collection

Experiences of the first year suggested the need to be clearer about the importance of providing a meaningful context for the data collection protocols. It cannot be taken for granted that when students gather data, they will have a conceptual framework for understanding the significance of the information they are obtaining. Nor do students necessarily understand the data visualizations on the GLOBE home page. The GLOBE program realized that it needed to do more in terms of providing learning activities that would present key concepts underlying the GLOBE protocols and stimulate the review of data and the use of visualizations and data from the archive to address student questions. The major strategy for addressing these needs was through the learning activities designed for the second edition of the Teacher’s Guide and, even more so, for the 1997 Guide revision. The investigation teams (science and education PIs) were instructed to develop activities that would help students understand why they were collecting data in a certain way (see, for example, the activity “Studying the Instrument Shelter” in the 1996 Teacher’s Guide) and to reflect on the data collected (see “Water, Water Everywhere!” in the 1997 Guide Supplement). In developing material for the 1997 Guide revision, teams were explicitly instructed to include at least one activity making use of the GLOBE student data archive or visualizations.

There was an effort also to support data analysis and interpretation through new capabilities on the GLOBE Web site. A “Compare” feature was added to allow users to view two visualizations side by side. This feature allows a student to look at student data and reference set data for the same region and variable or to examine the visualizations for two different but possibly related variables (such as temperature and precipitation).

GLOBE software developers added interactive features to the archives, enabling students to develop graphs from subsets of the student data or to develop and display two graphs for comparison purposes.

### Stimulating Broader Use of GLOBE Tools

During the 1995-96 school year, only 39% of teachers implementing GLOBE reported that their class used the visualizations. Fewer than 30% were telecommunicating with other GLOBE schools, and fewer than 45% said that they compared different sets of GLOBE data during a typical week. Two basic strategies were applied to stimulate a more comprehensive implementation of GLOBE. Primary was the development of new protocols and learning activities incorporating the use of tools such as the MultiSpec software, GLOBEMail, GLOBE data visualizations, and student data. As science and education PIs increased their communication with GLOBE system developers, Web tools and learning activities began to evolve in tandem. (Because of the time required to develop new tools and instructional activities, this collaboration's impact is more apparent in the 1997 Guide Supplement than in the 1996 Teacher's Guide.) In addition, although it was not uniform across training sites, a number of the GLOBE trainers made an effort to give more emphasis to the technology tools in GLOBE training, including a culminating activity in which teachers demonstrated their familiarity with all of the tools. A "tour" of the GLOBE Web site was developed to increase the likelihood that teachers would be aware of the resources available to them there.

The strategy for trying to spur implementation of the less frequently used data collection protocols was increased contact with the scientist principal investigators. GLOBE scientists had increased contact with teachers during 1996-97 through their involvement in GLOBE trainings and in pilot testing their new protocols and learning activities. In addition, technology supports were brought to bear to increase the contact and communication between GLOBE classrooms and GLOBE scientists. Although a Scientist Corner within the GLOBE Web site had provided messages from scientists to students in the program's first year, teachers felt the need for more interaction and a sense of immediacy in students' interactions with the scientists. Scientists' e-mail addresses were added to their messages on the Web site. In addition, live "Web chats" with several GLOBE scientists were held during the second school year. The principal investigator for the atmosphere and climate investigation held a Web chat in November 1996; the principal investigators for the soils and hydrology investigations held a chat in December 1996.

### Addressing Needs of Primary Grades

The bulk of U.S. students participating in GLOBE are at the upper elementary and middle school levels, and teachers at these grades seem to find GLOBE an appropriate complement to their required curricula. Primary grade (K-3) teachers find that many of the protocols assume skills (such as ability to work with fractions) that their students lack, and the learning activities in the first Teacher's Guide were generally not at an appropriate level for their students. During 1996-97, GLOBE science and education PIs were given the charge to develop learning activities specifically designed for younger GLOBE students. The resulting activities (see, for example, "Water Detectives") are included in the 1997 Guide Supplement. Chapter 5 contains descriptions of how GLOBE was adapted for very young students at one of our case study sites.

### Overview of This Report

This introductory description highlights the evolving nature of the GLOBE program. As the program has evolved, the evaluation has evolved with it, addressing emerging needs while at the same time providing a longitudinal perspective through the ongoing collection of some standard data elements. This report summarizes our findings from the second year of the evaluation. Our data were collected during school year 1996-97. We have included a description of some of the program changes under way during that same time period, but it should be noted that many of the refinements put in place during 1996-97 (e.g., the establishment of a large number of GLOBE training "franchises," new learning activities in the 1997 Guide Supplement) were not yet affecting significant numbers of GLOBE classrooms at the time of our data collection.

Chapter 2 contains a description of the data collection and analysis methods used in the evaluation. Chapter 3 provides documentation of the program's growth, in terms of teachers trained, data reported, and international participation. Chapter 4 examines another aspect of program growth, the implementation of new data collection protocols and learning activities, as well as use of a broader set of technology features. Chapter 5 discusses implementation issues surrounding GLOBE, drawing on responses to the teacher survey and on case study information. Chapter 6 discusses evidence for program influences on teachers and students. Chapter 7 brings together conclusions based on all of the data analysis and highlights issues for future program improvements.

# Chapter 2. Overview of Evaluation Methodology

In this chapter, we provide an overview of the data sources and methodology applied in our second-year evaluation activities.

The four main sources of information used—databases developed by GLOBE and our own teacher surveys, student surveys, and case studies—are described below.

## GLOBE Databases

**Master Database**. NOAA has maintained a master database of "registered" U.S. GLOBE schools since the project's inception. The initial database information comes from the school's GLOBE application. Data fields are added as the GLOBE teacher completes training, qualifying the school to submit data to the GLOBE data archives.[1] The master database includes the school's name and address, name and contact information for the GLOBE-trained teacher and the principal, the school level, and the date and location of the GLOBE teacher's training. At our request, an additional data element, the grade level or levels taught by the teacher, was added at the end of 1996. The master database was used to determine the numbers of teachers trained each quarter during 1996 (as described in the next chapter). In addition, we were able to use this data source to identify teachers who had signed up for GLOBE training but not yet completed their training. This group constituted the pool from which we recruited a comparison group of classes to participate in our assessment of what students learn from GLOBE (described in Chapter 6).

**Student Data Archive**. NOAA also maintains the central GLOBE database to which students submit their measurements. The data archive contains the name and location information for the school submitting the data, the type of data, the date on which the data were collected, and the specific readings. This database was used in the evaluation as a source for identifying active GLOBE schools for the case studies and for the teacher survey (as described below). We also calculated the number of U.S. and international schools reporting data during the 1996-97 school year, the frequencies with which

[1] International schools are not included in this database. They can be found on the GLOBE Web site once the Country Coordinator informs the GLOBE Office that a teacher has been trained and provides school contact information and the school's latitude, longitude, and elevation.

various data categories were reported, and the frequency distribution of school data reports, all presented in the next chapter.

**Help Desk Queries**. GLOBE maintains a Help Desk facility at NASA-Ames in Mountain View, California. An 800-number hotline for the GLOBE Help Desk was made available to teachers at their training and is listed on the GLOBE home page. NASA maintains a database of requests received, showing the medium through which they came in (i.e., hotline call, electronic mail, or Web query), as well as the month (later quarter) and nature of the query. These data are summarized in Chapter 5.

## Teacher Surveys

Information on how GLOBE is being implemented, the challenges involved in implementation, and the perceived effects on students was derived from teacher surveys conducted during April-May 1997. The full text of the teacher survey is available in the Appendix. For U.S. GLOBE teachers, the survey was made available in both hard copy form and on the World Wide Web. International teachers received the same survey in hard-copy form.

To better understand the workings and impacts of GLOBE when it is a significant part of a class's activities, we chose to focus in the Year 2 evaluation on classrooms that were active in collecting GLOBE data. We used the Student Data Archive to identify active schools. Keeping in mind that many schools batch their GLOBE data rather than submitting it on a daily or weekly basis, in March of 1997 we identified those schools (1) that had submitted data on at least six different occasions during 1996-97, with at least two submissions since January 1, 1997; (2) whose data included at least three different data categories (i.e., the most frequently reported categories of temperature and rain would not suffice by themselves); and (3) who had reported at least 75 measurements overall. Among U.S. schools, 327 met this criterion. The same criterion was met by 114 schools from 18 international partner countries. GLOBE teachers at all of these schools were asked to complete a survey (thus, technically speaking, this group comprises a census of active teachers rather than a sample). International GLOBE teachers completed the same survey as U.S. teachers, but it was distributed to them by their country coordinators (who handled any translation requirements) rather than by SRI.

For U.S. teachers, the survey procedures were the same as those used in 1996. A letter announcing the upcoming survey and explaining its purpose went out to all U.S.

teachers to be surveyed in late March. SRI mailed printed copies of the surveys on April 9, 1997. The cover letter and first page of the survey urged teachers who had World Wide Web access to complete the survey on the Web (the URL was provided). On April 25, nonrespondents were sent reminder postcards. In mid-May, a letter from Tom Pyke, the GLOBE Director, urged remaining nonrespondents to send in their surveys. During the last week of May, attempts were made to reach nonrespondents by telephone. On June 16, the instruments were taken off the Web, and no further follow-up attempts were made.

International teachers' surveys and instructions were sent to country coordinators in May by the GLOBE program office. Coordinators sent the surveys to the specified teachers, received the completed surveys, and mailed surveys back to SRI. Because of the timing with respect to summer breaks and the extra steps required for distributing and returning surveys internationally, international teacher surveys received through September 15 were accepted.

Table 2.1 displays the populations, samples, response rates, and effective samples for the teachers we surveyed. As the table indicates, strong response rates were achieved, with 85% of U.S. teachers and 57% of international teachers responding, for a combined response rate of 78%.

**Table 2.1**
**Teacher Survey Populations and Sample Sizes**

| ***Population*** | ***Population Size*** | ***Number Responding*** | ***Response Rate*** | ***Percent Responding on Web*** |
|---|---|---|---|---|
| Active U.S. teachers | 327 | 279 | 85% | 39% |
| Active international teachers | 114 | 65 | 57% | NA |

Among U.S. teachers responding to our survey, 39% used the World Wide Web version, a somewhat smaller proportion than that which used the Web for the 1996 survey. We attribute the reduced propensity to use the Web-based version in 1997 to the fact that the more comprehensive survey used this year was more susceptible to problems with screen display and connection interrupts than the shorter instrument used in 1996. Teacher responses to the survey items are discussed in subsequent chapters.

### The Comparative Study: Classroom Information Sheets, Student Surveys and Assessments

By the spring of 1997, some teachers had been actively implementing the GLOBE program for 2 years. At this point, it was reasonable to start to look for ways in which GLOBE had influenced their teaching and what their students learn. To represent the elementary, middle, and secondary levels, we elected to investigate classroom teaching practices and student learning at the 4th-, 7th-, and 10th-grades. Using the 1996 teacher surveys, we were able to identify active GLOBE teachers working with students at those grade levels. Telephone inquiries made of these teachers identified those who were still implementing GLOBE at one of the target grade levels. In this manner, we developed a potential sample of 89 GLOBE classrooms: 42 at the 4th-grade level, 23 7th-grade, and 24 10th-grade. Roughly half of these classes were recruited for the comparative study, with the goal of obtaining 380 student respondents for both the elementary and the middle/secondary assessments.

To provide a baseline against which to measure GLOBE's influence, we wanted to find comparable classes where GLOBE had not been implemented. Our strategy was to use the GLOBE Master Database to identify teachers who had signed up for GLOBE training but not yet completed their training or implemented the program. In this way, 30 non-GLOBE (or future GLOBE) teachers were identified at the 4th-, 7th-, and 10th-grade levels. When their cooperation in the study was sought, over 90% of these teachers agreed to participate in giving a survey and assessment to their students.

At the time of their recruitment, teachers in the survey sample were asked to indicate the number of 4th-, 7th, or 10th-graders in their single most active GLOBE class or club or in the class most like that in which they planned to implement GLOBE in the future (in the case of non-GLOBE teachers). Both GLOBE and non-GLOBE classes were offered $20 toward the purchase of refreshments if 90% or more of the students in the class returned completed surveys. Table 2.2 shows the number of classes and students in the target sample and the percentage of completed surveys for GLOBE and non-GLOBE classes.

**Table 2.2**
**Sample Sizes for Student Survey and Assessment**

| ***Grade Level*** | ***Teacher-Reported Population*** | | ***Number of Classes Represented*** | | ***Number of Students Reporting*** | | ***Percentage of Students Reporting*** | |
|---|---|---|---|---|---|---|---|---|
| | GLOBE | Non-GLOBE | GLOBE | Non-GLOBE | GLOBE | Non-GLOBE | GLOBE | Non-GLOBE |
| Fourth grade | 395 | 214 | 20 | 9 | 389 | 206 | 98% | 96% |
| Seventh grade | 446 | 260 | 14 | 8 | 239 | 244 | 54% | 94% |
| Tenth grade | 173 | 233 | 10 | 10 | 149 | 226 | 86% | 96% |

### Student Assessment Items

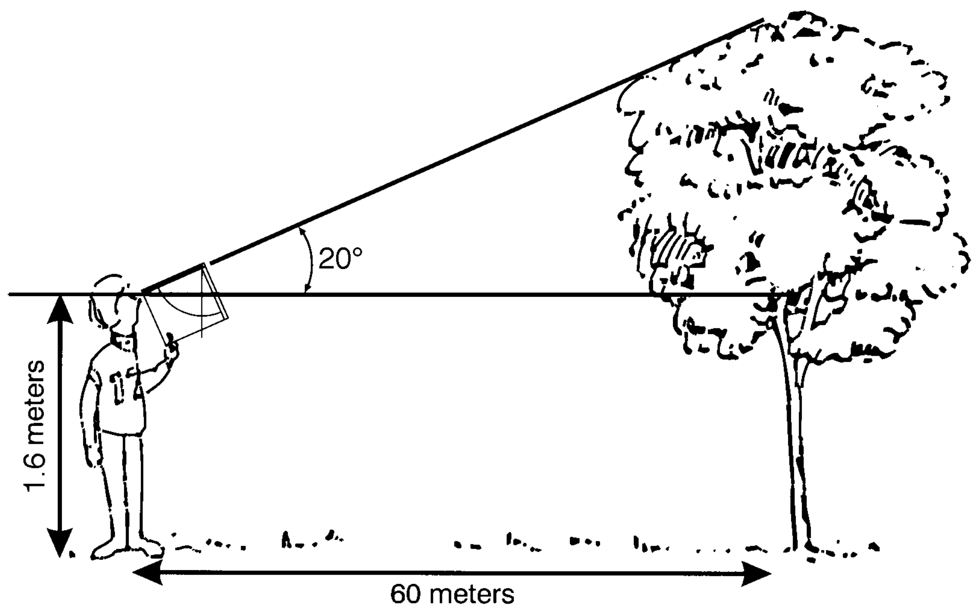
Because one of the objectives of the GLOBE program is to increase student achievement in science and mathematics, we concluded that the evaluation must provide measures of student learning. Our strategy for obtaining such measures was to combine a set of assessment items with brief student surveys. Items for the 1997 assessment were chosen from an item bank, which was started in 1996 and added to during the second year of the evaluation.

In developing assessment items, we took care to develop items that tested more than factual information. Typically, the items provided a context including an illustration or set of data with one or more questions addressing this problem context. Some of the items were modifications of items used on earlier state, national, or international assessments.

We developed a framework for developing items keyed to the GLOBE investigation areas and to three kinds of learning that could reasonably be expected to be promoted by GLOBE. The first item type concerned the ability to take accurate measurements of variables included in the GLOBE protocols. The second area concerned general knowledge of sound measurement principles, steps to increase the accuracy of an estimate, principles of sampling, and so on. The third area was the ability to interpret data, presented in graphs, tables, or narrative form, and to provide reasonable interpretations. Figures 2.1-2.3 provide samples of each type of item.

## Figure 2.1
## Example of Measurement Taking Assessment Item

**13a. The height of Tanya's eye level is 1.6 meters. She wants to know the height of a tree in her biology study site. She used her clinometer and found the angle to be 20°. She measured from where she was standing to the base of the tree and found it to be 60 meters.**




| Angle | Tangent |
|---|---|
| 15° | .27 |
| 16° | .29 |
| 17° | .31 |
| 18° | .32 |
| 19° | .34 |
| 20° | .36 |
| 21° | .38 |
| 22° | .40 |

**Using the table, help Tanya find the height of the tree.**

a. 22.0 m

b. 23.2 m

c. 20.0 m

*L004*
*L1e02_S*

d. 21.6 m

## Figure 2.2
## Example of Sampling and Measurement Principles Assessment Item

**9a. Two classrooms are located about 5 miles apart on the Pear River. Students in School A want to determine if the river water at their site is more acidic than the river water at School B. Mark the best way for the schools to collect samples of river water to answer this question.**

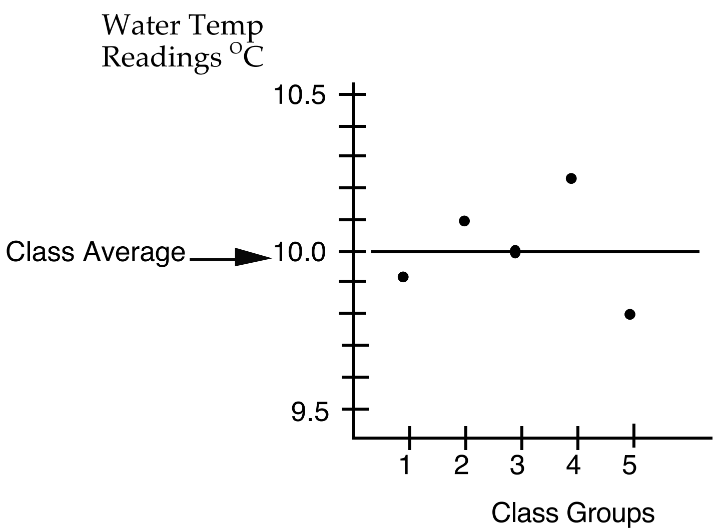
a. Collect a sample of water from School A's river site one day and a sample from School B's river site another day.

b. Collect a sample of river water from School A's site one day and a sample from School B's site on the same day.

c. Collect many samples of water from School A's river site one day and many samples from School B's river site on the same day.

*H2c07_S* d. Collect many samples of river water from School A's site and many samples from School B's site on several different days.

## Figure 2.3
## Example of Data Interpretation Assessment Item




**19c. What does the graph indicate?**

a. The thermometers need to be calibrated.

b. Water temperature is slowly rising.

c. Group 3 got the right reading.

*H022*
*H3a07_S* d. The class makes precise measurements.

We expected GLOBE students to show an advantage over non-GLOBE students in the area of taking GLOBE measurements (even though some non-GLOBE students employ similar measurement procedures in other environmental education programs). It was less clear whether students in classes implementing GLOBE would perform better on the second and third learning areas, which don't necessarily get the stress they deserve in either GLOBE or non-GLOBE science classrooms.

Jim Lawless, the GLOBE Chief Scientist during school year 1995-96, helped us develop initial pools of items (one for 4th-graders and one for 7th- and 10th-graders) related to the GLOBE I protocols. These items were pilot tested along with the 1996 student survey. (See the Year 1 Evaluation Report.) In the summer of 1996, the science and education PIs who had developed the GLOBE II protocols and learning activities worked with SRI staff to identify the important concepts students could learn through their investigations and to develop first drafts of assessment items appropriate for GLOBE II. These GLOBE II assessment items were reviewed and revised by staff with science assessment expertise and were pilot tested in four schools prior to inclusion in the item bank. For the 1997 student assessment, eight test forms were constructed from this item bank—four for administration to 4th-graders and four for administration to 7th- and 10th-graders. Because we were interested in measuring the performance of a grade-level population rather than of individuals, relatively few assessment items had to be included on each of the student surveys. Fourth-graders were given 15 assessment items and older students 20 items. Because we expect to use the assessment items in future evaluation activities, they are not presented in the Appendix, but student responses to the assessment items are described in Chapter 6.

## Classroom Information Sheets

GLOBE teachers whose students were in the comparative student assessment study were likely to be part of our teacher survey sample, providing us with extensive information about how they implemented GLOBE. We did not have a source of comparable information about what the non-GLOBE teachers had done in their classes, however, and wanted to have information about what experiences the students in their classrooms had had that would be relevant to the skills and knowledge tapped by our assessment items. At the same time, we were aware that GLOBE is not implemented in any uniform way, and we would not expect students in a GLOBE class that had not implemented a given protocol to show advantages in measures of that content area relative to students in a non-GLOBE class. A Classroom Information Sheet, administered to both GLOBE and non-GLOBE teachers, asked whether or not 13 environmental science topics had been covered in their classes. For each topic teachers said they had covered, they were asked to indicate what their students had been expected to do:

- Learn vocabulary and concepts
- Do observations or take measurements
- Apply concepts by generating hypotheses or experiments
- Analyze and compare data on these topics, making inferences and explaining findings.

### Student Survey Items

Before answering the assessment items, students in the comparative study were given a set of questions aimed at revealing their attitude toward science, the kinds of activities they engaged in during science class, and their concept of what it means to do science. The latter item was adapted from the Epistemological Questionnaire used by University of California, Berkeley, researchers Marcia Linn and Betsy Davis in their investigations of students' science learning (Songer & Linn, 1991). The student survey items can be found in the Appendix.

### Case Studies

Our research plan included site visits and the development of snapshot case studies for five sites. Given the evolution of the GLOBE program and the issues identified in the first year's evaluation, we decided to select schools for case study that represented specific strengths in areas of concern to the program as a whole. The strengths we sought to represent were:

- Active program at the primary level
- Multi-school program
- Multidisciplinary program
- Multi-teacher high school program
- Active urban program.

Responses to the 1996 teacher survey were used to identify candidate sites in each category. The level of activity in reporting data during the 1996-97 school year was checked in the Student Data Archive. Those schools continuing active implementation of GLOBE remained as candidates for case study sites. Phone interviews with the lead teacher at the most active schools in each category were used to make final selections.

Site visits were conducted between March and May 1996. Each visit was scheduled for a 3-day period and included interviews of GLOBE teachers, observations of GLOBE activities, informal discussions with students, and interviews with administrators who had been most involved in getting the program in place within the school.

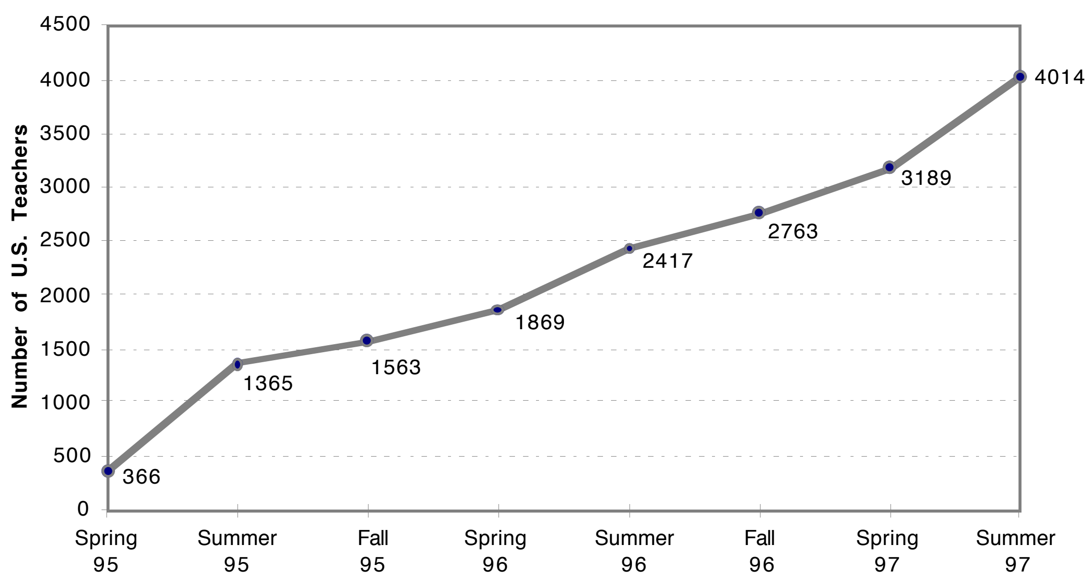
# Chapter 3. Program Growth

In this chapter, we describe the growth of the GLOBE program during its second year. We focus here on quantitative indices of program growth, including the number of teachers trained, the number of schools reporting data, and the number of readings of each type reported each month. Wherever possible, we make comparisons across Years 1 and 2. Chapter 4 discusses more descriptive indices of the program's increasing depth, such as the numbers of protocols and learning activities implemented by teachers and usage rates for features of the GLOBE Web site.

## The Number of Teachers Trained

Since the inception of the program in 1995, GLOBE has emphasized the importance of teacher training. By September 1997, roughly 5,000 teachers, including 1,000 teachers outside the U.S., had received GLOBE training. Teacher training in the U.S. ramped up very quickly, as shown in Figure 3.1. Between spring 1995 and spring 1996, more than 1,800 U.S. teachers were trained. Between summer 1996 and summer 1997, GLOBE trained roughly another 2,000 U.S. teachers, bringing the total to 4,014 (see Figure 3.1). Of these, 242 were trained by a GLOBE "franchise" rather than directly by the GLOBE program. The 4,014 trained teachers in the U.S. represent 3,100 GLOBE schools.

**Figure 3.1**
**Cumulative Growth in Number of U.S. Teachers Trained for GLOBE**



### Number of Reporting Schools

If the GLOBE program is to succeed, teachers must go beyond completing training to actually implementing the program in their classrooms. Although GLOBE is more than the collection and reporting of environmental data, the sharing of that data over the Internet is certainly central to the program. Accordingly, we examined the number of schools reporting data and the average amount and number of types of data contributed by each school. These analyses are based on monthly data summaries prepared by NOAA's Forecast Systems Labs.[1]

Figure 3.2 shows that the average number of schools reporting data per month increased during the 1996-97 school year from 529 schools in September to 1,011 in May. Although this increase is dramatic, it is not as steep as in the preceding academic year (1995-96), when the number of schools reporting data rose from 170 in September to 792 in May. In both years, an increasing number of schools reported data each successive month from September through April or May, and then reporting dropped off during the typical school vacation months of June through August.

The lion's share of the increase in number of schools reporting in Year 2 over Year 1 is attributable to increasing international participation. In April 1997, for example, the increase in number of schools reporting over the prior April was 271, comprised of an increase of 51 for U.S. schools and 215 for international schools.

### Reporting Patterns for Various Types of Data

In the GLOBE program, students are encouraged to take various specified measurements and to submit their data at prescribed times during the school year. To meet the needs of both scientists and teachers, students were instructed to take atmospheric measurements (air temperature, cloud cover and type, rain, and snow precipitation) daily and to take other measures, such as soil moisture and hydrology measurements, on a monthly basis at a minimum.[2] On the other hand, most of the biometric information is to be gathered seasonally.

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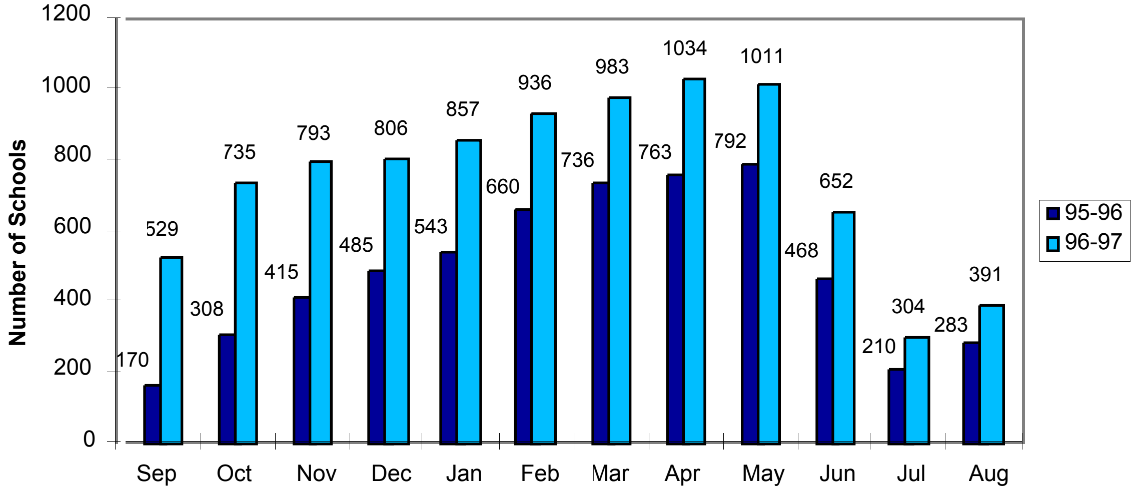
[1] Our thanks to Michael Turpin for his help in preparing these data.

[2] The schedules for hydrology protocols changed from weekly intervals in Year 1 to monthly intervals in Year 2 and for the new soil moisture protocol from daily to monthly.

**Figure 3.2**
**Number of Schools Reporting Data in GLOBE Years 1 and 2**




To examine the data reporting patterns for specific types of data, we first separated the measurements taken (and reported) into two groups (i.e., daily atmospheric measurements vs. other measurements) and charted the results separately for each group. Figure 3.3 shows the total number of schools submitting reports for each type of daily measurement (i.e., air temperature, clouds, rainfall, and snow) by month for each of the two years the program has been in operation.[3] According to Figure 3.3, the number of schools submitting air temperature, cloud, and rainfall reports generally increased as the academic year progressed during both Years 1 and 2, with the most schools submitting reports on clouds and air temperature and the fewest on snowfall. The number of schools submitting snowfall reports drops off after March or April, as winter ends in the Northern Hemisphere. A comparison of the Year 2 with Year 1 data for these daily measurements indicates that greater numbers of schools were reporting data on all four measures each month during Year 2.

Figure 3.4 shows the number of schools reporting soil moisture and hydrology data for both academic years.[4] Overall, the numbers of schools reporting these data types

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[3] NOAA's data summary treats Cloud Cover and Cloud Type data as a single report, here labeled simply Clouds.
[4] NOAA's data summary lumps together the various hydrology protocols (Water Temperature, pH, Dissolved Oxygen, Alkalinity, etc.), counting all those submitted at the same time as one report regardless of the number of pieces of data submitted on the Hydrology report form.

**Figure 3.3**
**Number of Schools Reporting Atmospheric Data, by Type, Month, and Year**

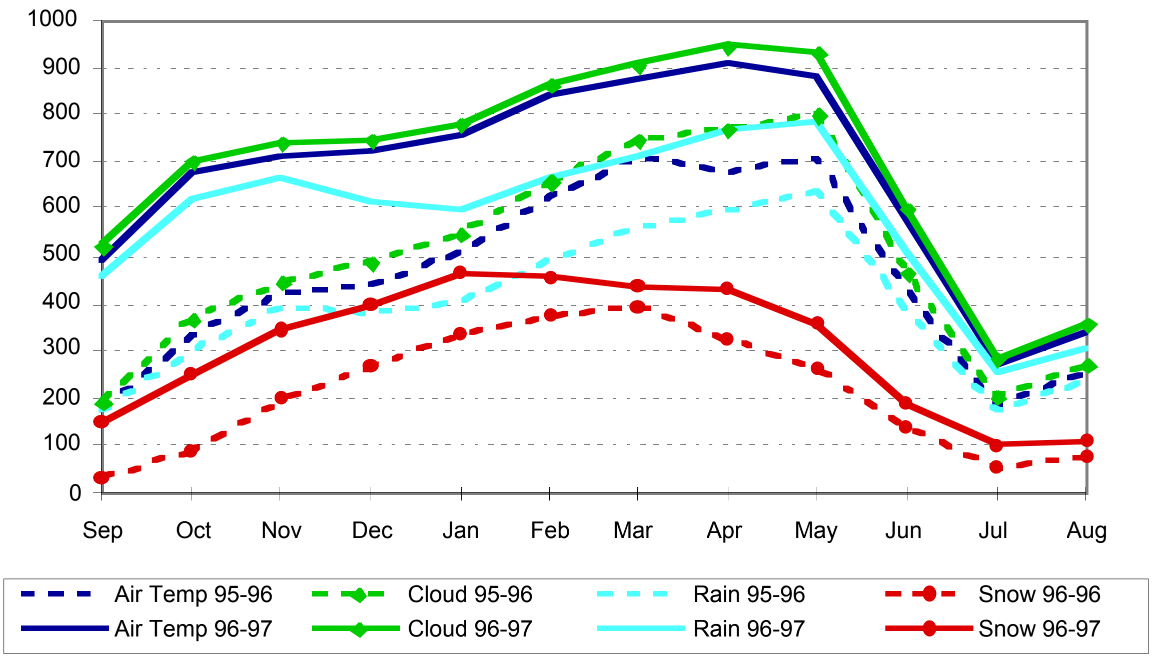
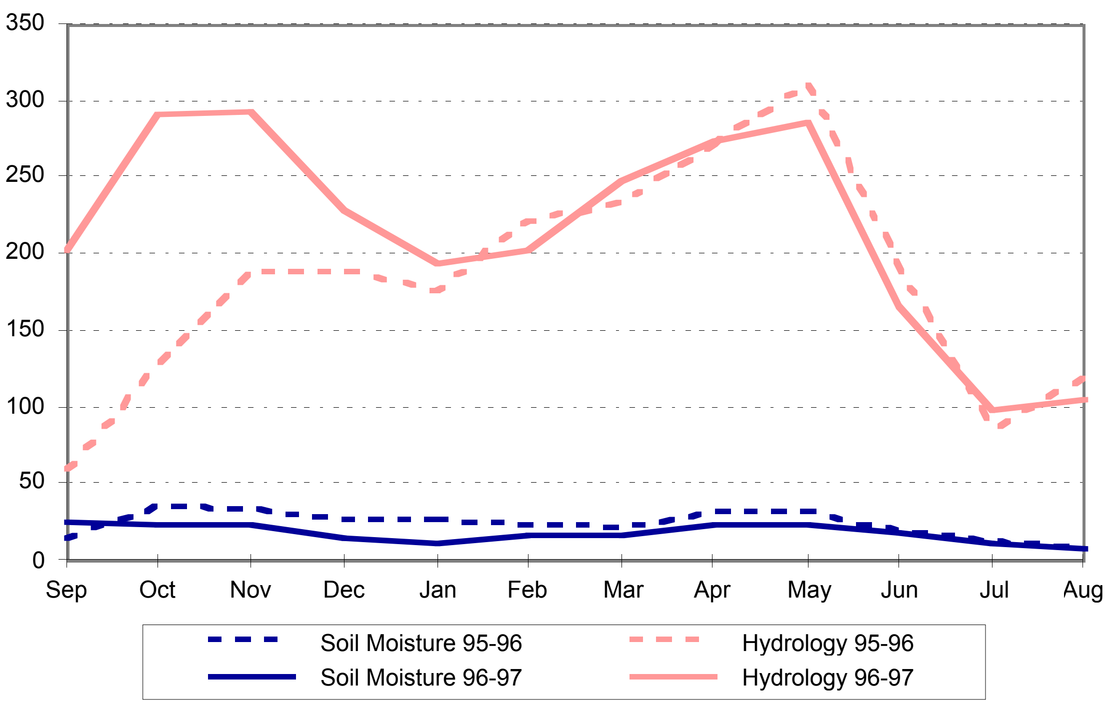



**Figure 3.4**
**Number of Schools Reporting Soil and Hydrology Data, by Type, Month, and Year**



were lower than those for the atmospheric measurements plotted in Figure 3.3. In both years, the number of schools reporting hydrology data increased sharply from September to October or November, then leveled off or declined during the cold-weather months in the Northern Hemisphere, and rose steeply in the spring (until May and the onset of the summer drop-off). The number of schools reporting soil moisture data has never exceeded 40 in a single month and has been fairly constant across calendar months, except for the summer dip seen for all data types.

The total number of schools reporting data does not provide information about each reporting school's level of participation. Scientists generally prefer a smaller number of more complete data sets to a large number of fragmented ones. To get an estimate of school participation levels, we calculated the average number of data reports made by those schools that were reporting data each month and plotted the results in Figures 3.5 and 3.6.

As can be seen in Figure 3.5, the average number of air temperature, cloud, snow, and rainfall readings reported by participating schools was higher in September 1996 than in September of the preceding year. It is interesting to note that while the number of schools reporting data drops off in the summer (as seen in Figure 3.3), those schools that do submit data in the summer months provide just as many reports per month as schools do during the rest of the year.

According to Figure 3.6, although very few schools are reporting soil measurements during the year, the average number of reports for those that do contribute data is high—averaging more than 10 reports a month. The average numbers of data reports per school in July and August, which were very high, are not included in Figure 3.6 because they are based on 10 or fewer schools (as shown in Figure 3.4).

During both years, the schools providing hydrology data submitted an average of 2 to 6 hydrology reports per month (again counting all hydrology readings for the same day submitted at one time as a single report). In comparing Year 1 and Year 2 soil moisture and hydrology data, it should be remembered that the stipulated frequency of data collection dropped from weekly in GLOBE I to monthly in GLOBE II (although weekly reports are still termed "desirable") and that the GLOBE II gravimetric soil moisture measurements are single monthly measures rather than four daily measurements as called

**Figure 3.5**
**Average Number of Atmospheric Data Reports Made per School Each Month**

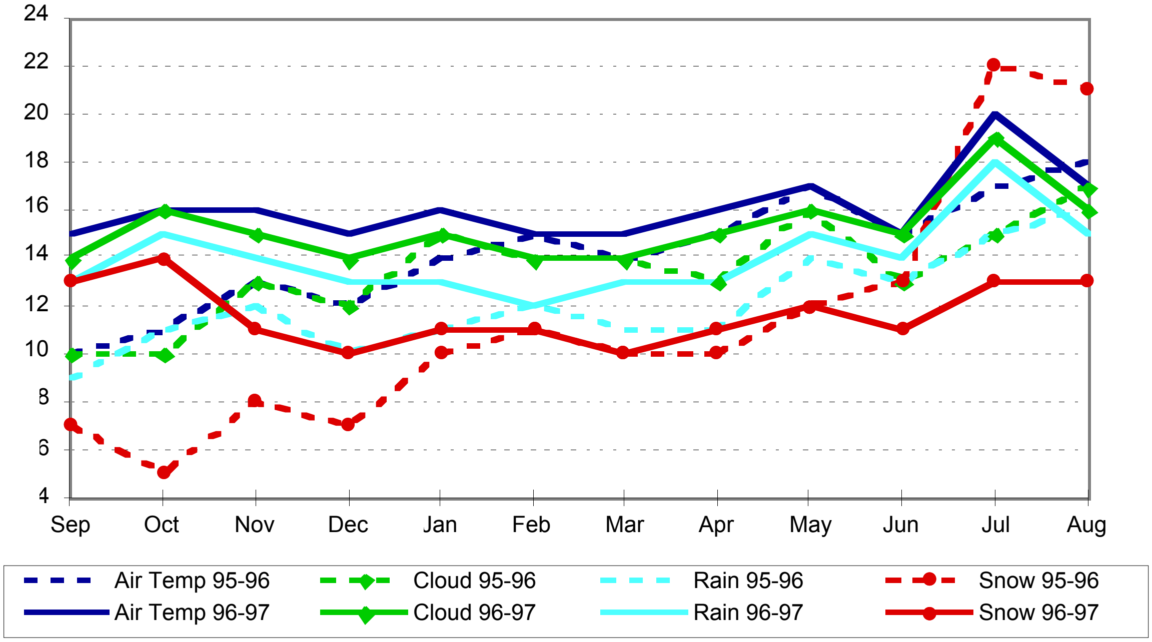
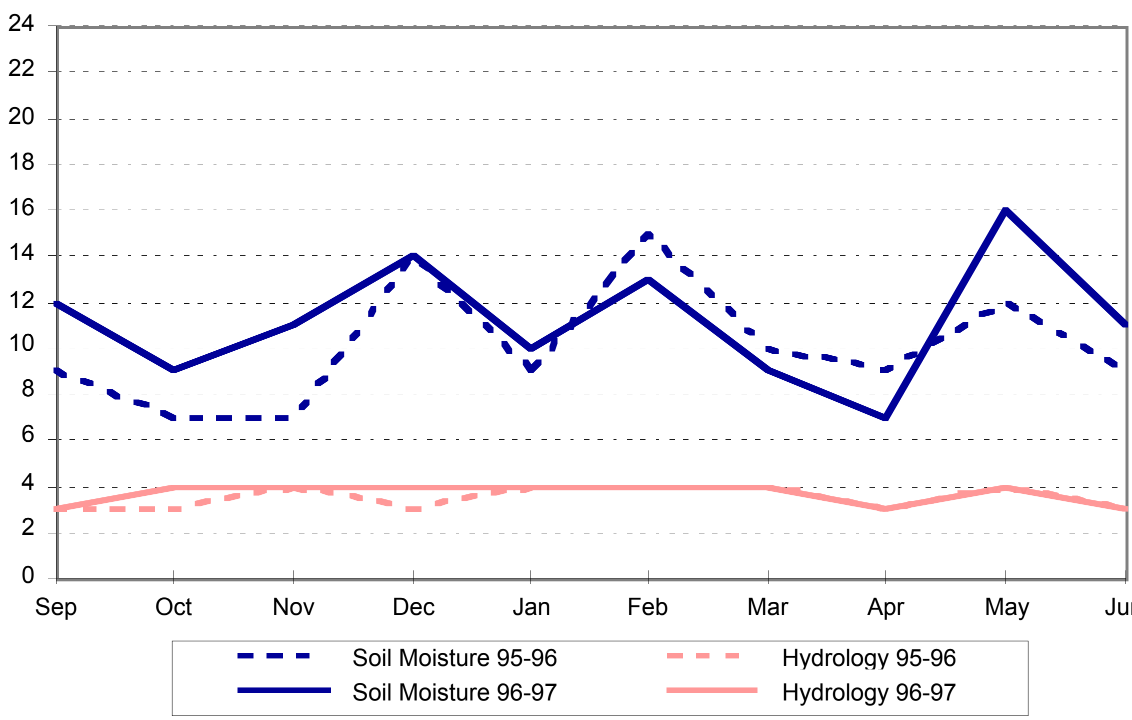



**Figure 3.6**
**Average Number of Soil and Hydrology Data Reports Made per School Each Month**



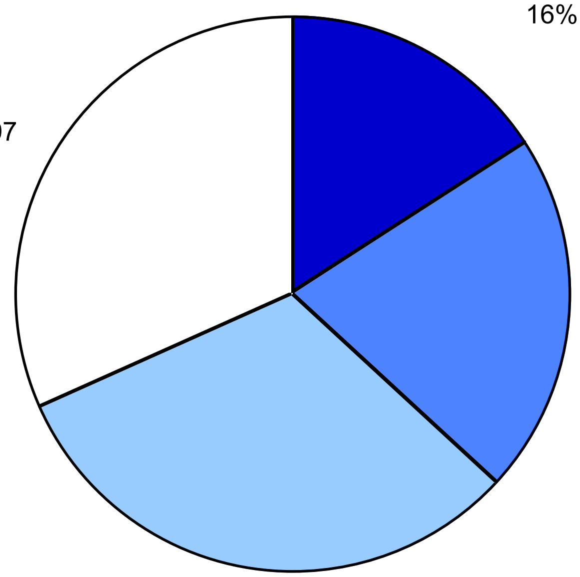
for in the GLOBE I gypsum block protocol. Some schools continued to use the GLOBE I soil moisture protocol during 1996-97, however.

### Data Reported per Trainee

Of the 3,100 U.S. schools that have had one or more teachers trained as of September 1997, nearly 1,500 had reported data to the Student Data Archive as of that month. It would be misleading to calculate the percentage of schools reporting data based on these numbers since they include a large number of schools whose teachers had just received their training in the summer of 1997. Typically, there is a considerable lag between completion of GLOBE training and classroom implementation to a point where data are actually submitted (see the Year 1 Evaluation Report for a discussion of start-up issues). Instead, we followed up on those 2,000 schools that were first to have at least one teacher trained, all of which had a trained GLOBE teacher no later than summer 1996. Of these, 60% have reported GLOBE data at least once. It would be unrealistic to expect *every* trained teacher to result in a reporting school, and it should be kept in mind that a teacher's classes may benefit from GLOBE activities even if no data are reported. (In the spring 1996 survey of a representative sample of teachers who had completed GLOBE training in 1995, 70% described themselves as having "implemented GLOBE with students" by spring of 1996.) Nevertheless, this measure of training "productivity" suggests that GLOBE is putting a great deal of effort into training teachers who do not fully implement the program.

Another perspective on data reporting is provided by looking at continuity across years. We were interested in knowing whether those schools that had reported data in 1995-96 were continuing to report data and submitting additional types of data during 1996-97. Figure 3.7 shows the Year 2 reporting behavior of the 910 U.S. schools that began reporting data in school year 1995-96. In 1996-97, 143 of these schools reported more data types than they had in the preceding academic year. This finding illustrates that without any additional training, many teachers increased their involvement in the GLOBE program by revising their curriculum to accommodate additional measures. One hundred and ninety-two schools exhibited steady involvement by reporting the same number of data types during both years. On the other hand, 287 of these schools reported fewer data types in 1996-97 than in 1995-96, and 288 schools failed to report any data in the second year, for an "attrition rate" of 32%.

**Figure 3.7**
**1996-97 Data Reporting Profile for U.S. Schools Reporting GLOBE Data in 1995-96**



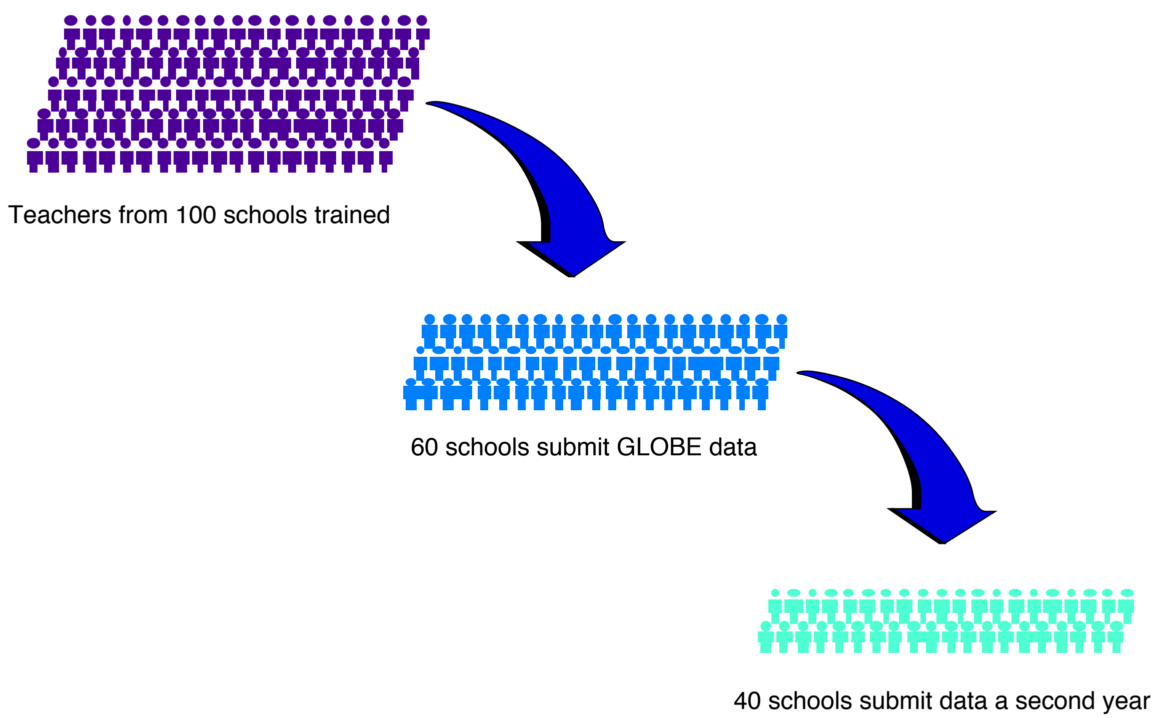

Put another way, the school retention rate was 68%, obtained by combining the three positive reporting categories.  Out of the total number of U.S. schools that reported data in 1996, 68% also reported data in 1997.  To the extent that other environmental education programs have maintained data on retention, GLOBE's record compares favorably.[5]

At the same time, it should be acknowledged that, from the standpoint of building a useful set of data for scientific purposes, there is ample room for improvement.  The retention rate between Years 1 and 2 described above can be combined with the

[5] We contacted four major environmental education programs that had been in existence for 5 years or more:  National Project WET (Water Education for Teachers); GREEN (Global Rivers Environmental Education Network); Project WILD; and Kids as Global Scientists.  Kids as Global Scientists was the only program with data on teacher retention rates from year to year.  With their much smaller program and extensive phone contact with program staff, they have experienced retention rates (percentage of teachers implementing the curriculum the next year) ranging from 31% to 46% over their 5 years of operation.  GREEN, which reported that it has trained 30,000 teachers in its 13 years of operation, estimates that about 600 teachers are currently active.

proportion of trainees who later report data to estimate "training productivity" for the GLOBE data reporting pipeline. This calculation is illustrated in Figure 3.8. For every 100 schools from which teachers are trained, experience suggests that around 60 will eventually contribute to the GLOBE database. Of those 60 schools, we can expect about two-thirds (i.e., 40 schools) to report data during a second year.

**Figure 3.8**
**Projections Relating Teacher Training to Data Reporting**




The breadth and continuity of the data sets contributed by GLOBE schools may change significantly as more schools have multiple teachers trained. Our spring 1997 sample did not have large numbers of teachers from schools where more than one teacher had received training from GLOBE (the effects of the new emphasis on training multiple teachers should be more apparent in the spring 1998 sample). An encouraging sign (albeit one officially beyond the time frame covered by this report) is the fact that a larger proportion of schools with multiple teachers trained by GLOBE than of schools with a single GLOBE-trained teacher had reported fall 1997 data by October 22 of this year. Whereas just 22% of schools for which one teacher had been trained had reported data by that date, 25% of those with two or more teachers trained and 33% of those with three or more teachers trained reported data between September 1 and October 22, 1997, according to GLOBE records.  The third year of the evaluation will address the impacts of training multiple teachers per school in greater detail.

# Chapter 4. Incorporation of New Materials and Resources

In this chapter, we summarize another aspect of the growth of the GLOBE program—teachers' incorporation of new data collection protocols, educational activities, and technology resources into their teaching.

## Incorporation of GLOBE II Protocols

As described in Chapter 1, the GLOBE Teacher's Guide was thoroughly revised during 1995-96, with a draft of the second-edition guide being used in summer 1996 training and the final version distributed to all GLOBE teachers in November 1996. As shown in Table 1.1 (in Chapter 1), the number of GLOBE data collection protocols was greatly expanded from Year 1 to Year 2.

Where protocols were retained, there were often refinements that tended to make the measurement more straightforward. To take the most extreme example, the Soil Moisture protocol in GLOBE I was based on measuring the electrical conductivity of gypsum blocks, buried at various depths within the study site. GLOBE classes had to construct their own calibration curves, which they then used to convert their meter readings of conductivity into a measure of soil moisture. Only recommended for high school students, the initial setup procedures were time consuming and complex, and the whole protocol was error-prone. In GLOBE II, the primary Soil Moisture protocol involves weighing soil samples before and after oven drying (gravimetric procedure) to determine how much of the initial weight was due to water. The gypsum block method is still an option, but students are instructed to report their meter readings directly to the GLOBE database (their calibration curves are submitted also, but the students submit the raw data, applying the calibration curve to their conductivity reading as an in-class activity to help them understand the meaning of their data).

These refinements reflected lessons learned in GLOBE's first year. Jim Lawless, the GLOBE Chief Scientist for the 1995-96 school year, observed that the first year's experience had brought home the point that the protocols themselves should be as straightforward as possible. If instrument readings need to be converted into a different unit of measurement or a conversion or correction factor needs to be applied to readings, software can be written to perform the operation on raw data submitted into the database. The more conversions or other arithmetic operations that need to be applied to a measurement, the more likely it is that human error will get into the data archive. (This is true for professional data collectors as well as for students.)

Although considerable effort was made to make GLOBE II protocols "user friendly," this effort did not result in quick adoption. Phone interviews of 112 GLOBE teachers conducted between November 1996 and January 1997 to solicit early feedback on the second edition of the Teacher's Guide found that at that time few teachers had implemented GLOBE II protocols that had not been part of GLOBE I. In fact, in the fall of 1996, fewer than 15% of the teachers interviewed had implemented any GLOBE II protocols from investigations other than Atmosphere. Moreover, a significant proportion (25%) of the phone interviewees said that they had not yet had time to start reading the second edition of the Teacher's Guide. On the positive side, 75% of these interviewees had read some portion of the guide within 1-3 months of receiving it.

Knowing that implementation rates for the new material were a significant issue, we devoted a considerable portion of the spring 1997 teacher survey to questions about implementation history and intentions for the GLOBE II protocols and learning activities.

Responses on the spring 1997 survey indicated that the overwhelming majority of teachers (88%) had referred to the second-edition Teacher's Guide at least once by the end of the school year. Table 4.1 shows the self-reported implementation rates (and intentions) for GLOBE II protocols that were revisions of protocols included in GLOBE I. (The implementation rates reported on the teacher survey differ from the proportion of schools reporting data on a given variable both because our survey sample represents "active" teachers rather than all teachers and because some classes collect data that they do not enter into the GLOBE database.) Implementation rates for the Atmosphere protocols, all of which had been part of GLOBE I in some form, were quite high, with the exception of the GLOBE II Solid Precipitation (snowfall) protocol, which was both changed since GLOBE I and relevant to only a subset of GLOBE schools. (Schools in locations where it does not snow can report "0" solid precipitation but are unlikely to go through the motions of implementing the measurement protocol.)

Table 4.2 shows implementation history and intentions for those protocols that were not part of GLOBE I. The implementation rates for these new protocols are much lower than those for the protocols in Table 4.1. In fact, as of the time of the spring 1997 survey, seven of the eight new GLOBE II protocols had been used by fewer than 15% of active

**Table 4.1**
**Implementation Rates and Plans for More Familiar GLOBE II Protocols (Percent)**

| | *Implementation Plans* | | | |
|---|---|---|---|---|
| ***Protocol*** | ***Have Implemented*** | ***Definitely Will Implement*** | ***Might Implement*** | ***Definitely Will Not Implement*** |
| Min/Max/Current Temperature | 97 | 2 | 1 | <1 |
| Rainfall | 95 | 4 | 1 | <1 |
| Solid Precipitation | 76 | 10 | 7 | 7 |
| Cloud Cover | 97 | 2 | 2 | <1 |
| Cloud Type | 97 | 2 | 2 | <1 |
| Water Temperature | 69 | 16 | 10 | 6 |
| Water pH | 68 | 16 | 10 | 6 |
| Establish Study Sites | 69 | 17 | 11 | 4 |
| Land Cover Mapping | 35 | 37 | 22 | 6 |
| Species Identification | 50 | 32 | 15 | 3 |
| Biometry | 46 | 31 | 18 | 6 |
| GPS Measurement | 70 | 19 | 8 | 3 |

Sample sizes: $325 \leq n \leq 344$.

**Table 4.2**
**Implementation Rates and Plans for Less Familiar GLOBE II Protocols (Percent)**

| | *Implementation Plans* | | | |
|---|---|---|---|---|
| ***Protocol*** | ***Have Implemented*** | ***Definitely Will Implement*** | ***Might Implement*** | ***Definitely Will Not Implement*** |
| Dissolved Oxygen* | 17 | 31 | 28 | 24 |
| Alkalinity* | 14 | 30 | 29 | 26 |
| Electrical Conductivity* | 14 | 26 | 30 | 31 |
| Qualitative Validation Data | 13 | 35 | 37 | 15 |
| Quantitative Validation Data | 11 | 36 | 39 | 15 |
| Accuracy Assessment | 8 | 36 | 43 | 14 |
| Soil Moisture | 14 | 23 | 34 | 30 |
| Soil Characterization | 8 | 28 | 36 | 29 |

Sample sizes: $307 \leq n \leq 327$.

* Elementary school classes were not asked to perform Dissolved Oxygen, Alkalinity, or Electrical Conductivity protocols.

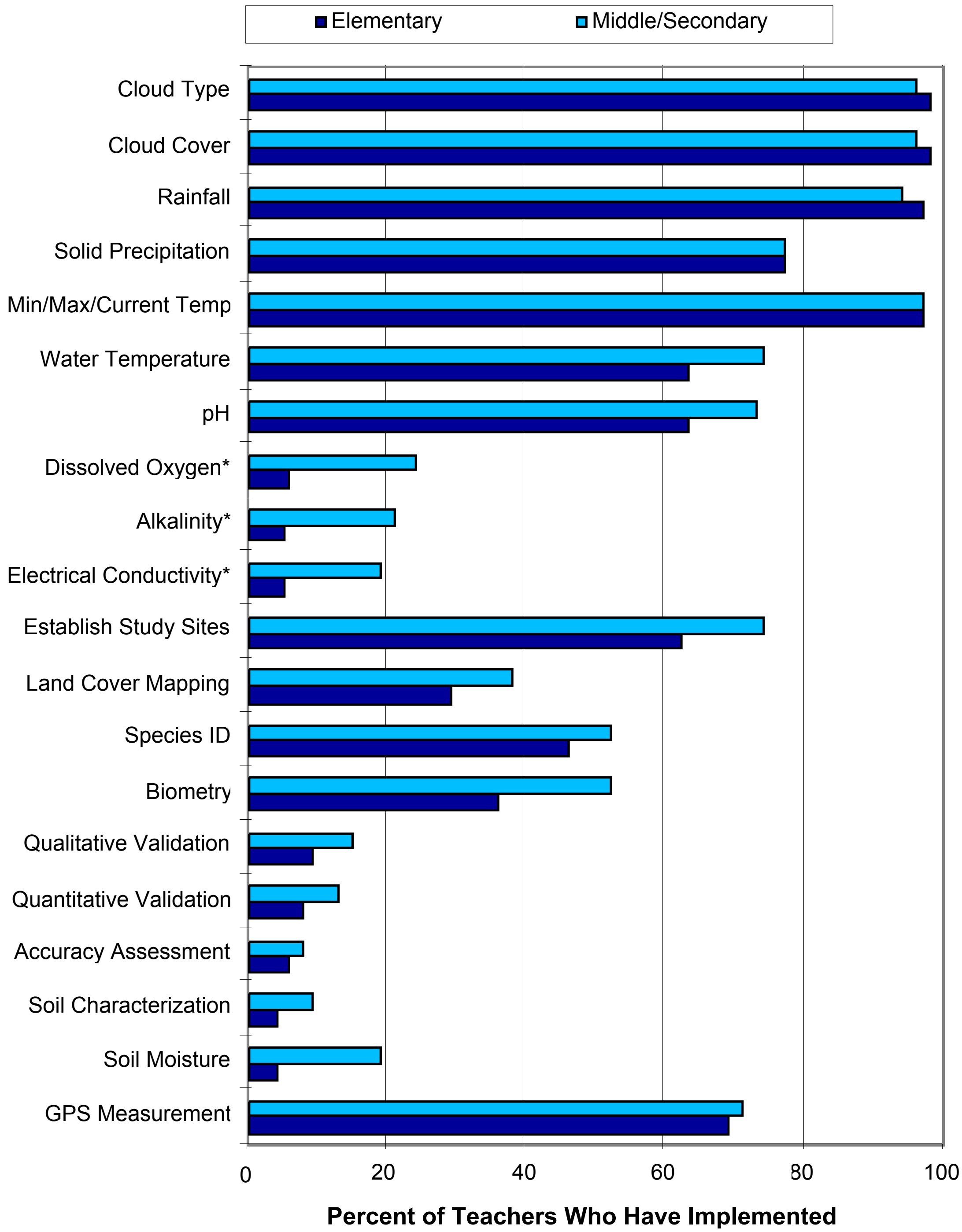
GLOBE teachers. We examined the implementation rates separately for those teachers trained before and after June 1996 to see whether those teachers trained with GLOBE II materials would be more likely to implement the new protocols. The teachers trained on GLOBE II did have somewhat higher implementation rates than teachers trained with GLOBE I materials for the three GLOBE II Hydrology protocols. For the most part, however, teachers trained earlier (i.e., with GLOBE I) had higher implementation rates, highlighting the importance of time and experience with the program.

We examined protocol implementation rates by grade level, contrasting the proportion of elementary school teachers with that for middle and secondary school teachers combined. There were significant differences between the two groups, with a higher implementation rate at the upper grade levels for the Water Temperature, Water pH, Dissolved Oxygen, Alkalinity, Electrical Conductivity, Land Cover Mapping, Qualitative Validation Data, Quantitative Validation Data, Accuracy Assessment, Soil Characterization, and Soil Moisture protocols.[1] Even so, the upper grades' implementation rates outside of the Atmosphere investigation were not particularly high, as shown in Figure 4.1.

In Year 1, the GLOBE program encountered the fact that initial program implementation can lag behind training for many months. The second year's experience suggests that it takes time to incorporate new protocols into a local GLOBE program, even for veteran GLOBE teachers. Implementation rates are likely to rise for the new GLOBE II protocols among this set of teachers during school year 1997-98. A projection of the proportion of these teachers who will be implementing the protocols next year can be obtained by adding those who "definitely" plan to implement to those who have already implemented the protocol. (Certainly, some of those who reported that they "might implement" a protocol will in fact do so, but given the propensity of survey respondents to provide the answers they believe the survey taker wants to hear, we adopt a conservative approach to implementation projections.) The sum of those with a "definite" intention to implement and those who have already done so is more than 80% for 10 of the 20 GLOBE II protocols. On the other hand, 40% or fewer of active GLOBE teachers have implemented or have definite intentions to implement 3 of the 20 (Electrical Conductivity, Soil Characterization, and Soil Moisture). The highest expected increase in implementation (i.e., largest difference between current and anticipated

[1] Elementary school classes were not asked to perform Dissolved Oxygen, Alkalinity, or Electrical Conductivity protocols.

**Figure 4.1**
**Protocol Implementation by Grade Level**




* Elementary school classes were not asked to perform Dissolved Oxygen, Alkalinity, or Electrical Conductivity protocols.

implementation rates) is found for the Land Cover/Biology protocols (Land Cover Map, Species Identification, Biometry, and the interrelated protocols of Qualitative Validation Data Collection, Quantitative Validation Data Collection, and Accuracy Assessment).

Searching for factors related to protocol implementation rates, we examined teachers' responses to questions about how well prepared they feel to implement GLOBE II protocols.  With the exception of the Soil protocols, a majority of teachers feel at least adequately prepared to implement the data collections, as shown in Table 4.3.  Looking beyond the data summary, we compared the perceptions of their preparation of teachers trained before the introduction of the GLOBE II materials in June 1996 with those trained afterward.  It may be that teachers feel ill-prepared to implement something they did not

**Table 4.3**
**Teachers' Perception of Their Level of Preparation for Implementing GLOBE II Protocols (Percent)**

| | ***Preparedness Rating*** | | | |
|---|---|---|---|---|
| ***Investigation Area and Training Time*** | ***Fully Prepared*** | ***Adequately Prepared*** | ***Partially Prepared*** | ***Definitely Not Prepared*** |
| *Atmosphere Protocols* | *64* | *30* | *6* | *<1* |
| Pre-June '96 training | 65 | 30 | 5 | 0 |
| Post-June '96 training | 64 | 30 | 6 | 0 |
| *Hydrology Protocols* | *46* | *36* | *16* | *2* |
| Pre-June '96 training | 48 | 37 | 14 | 2 |
| Post-June '96 training | 41 | 31 | 24 | 5 |
| *Land Cover/Biology Protocols* | *34* | *40* | *22* | *4* |
| Pre-June '96 training | 36 | 40 | 21 | 3 |
| Post-June '96 training | 29 | 46 | 22 | 3 |
| *Soil Protocols* | *17* | *28* | *36* | *20* |
| Pre-June '96 training | 15 | 28 | 37 | 20 |
| Post-June '96 training | 26 | 27 | 31 | 16 |
| *GPS Protocols* | *45* | *37* | *13* | *5* |
| Pre-June '96 training | 46 | 37 | 14 | 3 |
| Post-June '96 training | 40 | 40 | 10 | 10 |

Sample sizes: trained pre-June '96 = $263 \le n \le 275$; trained post-June '96 = $55 \le n \le 63$.

see demonstrated in training. If this is so, sending out revised Teacher's Guides and expecting GLOBE teachers to implement the new protocols contained in them would be ill-advised. When we split our sample into those trained before June 1996 (with GLOBE I protocols) and those trained after (with GLOBE II), however, we found that the differences did not favor those trained on GLOBE II (as shown in Table 4.3). Where differences did occur, there tended to be higher ratings of preparedness among those teachers trained *before* June 1996. The one exception is the GLOBE II Soil protocols, for which 53% of those trained with GLOBE II materials feel at least adequately prepared, compared with 43% of those trained earlier. These implementation rates can be expected to rise over time (and do include three protocols which are not recommended for the elementary level). Nevertheless, implementation rates are low enough to warrant careful monitoring and to suggest the value of further investigation of the factors influencing teachers' selection of protocols for implementation. (Teachers' rationales for selecting some protocols and learning activities over others are discussed later in this chapter.)

### Use of GLOBE II Learning Activities

An issue that emerged during the program's first year of operation was the emphasis on collection of data to the extent that educational context appeared to get short shrift. GLOBE I training included all the data collection protocols and very few learning activities (with the number trained left up to the particular training team). The program office made a concerted effort to promote more training of learning activities in GLOBE II. Nevertheless, it should be remembered that the learning activities have always been viewed as "voluntary," and the expectation is that teachers will select those activities that fit with their local curriculum and their students' needs. Even so, it would have to be said that the implementation rates for the GLOBE II learning activities are low, as shown in Table 4.4. Fifteen of the 35 learning activities had been implemented by fewer than 10% of the active GLOBE teachers as of spring 1997. There were some highly implemented activities, however. The highest implementation rate for any learning activity was 82% for Observing, Describing and Identifying Clouds (which was similar to an activity in the first version of the guide and one of the activities most often taught in training workshops).

Comparing implementation rates for elementary teachers with those for middle and high school teachers, we found significant differences favoring the higher grade levels for the Building a Thermometer, Bird Classification, Working with Angles, and Offset GPS Measurement activities. Although teachers were differentially likely to implement these protocols, depending on the grade level of their students, none of the grade-level implementation rates exceeded 20%. The Study the Instrument Shelter activity, on the other hand, was implemented in 70% of elementary school classrooms, a significantly higher rate than the 50% found for middle and secondary school classes ($p < .01$).[2]

**Table 4.4**
**Implementation Rates and Plans for GLOBE II Learning Activities (Percent)**

| Activity | Implementation Plans | | | |
|---|---|---|---|---|
| | ***Have Implemented*** | ***Definitely Will Implement*** | ***Might Implement*** | ***Definitely Will Not Implement*** |
| *Atmosphere* | | | | |
| Observe/Describe/Identify Clouds | 82 | 8 | 8 | 1 |
| Estimate Cloud Cover | 69 | 15 | 14 | 2 |
| Study Instrument Shelter | 57 | 14 | 21 | 9 |
| Precipitation | 30 | 22 | 38 | 10 |
| Building Thermometer | 14 | 20 | 46 | 20 |
| Land/water/air | 24 | 25 | 42 | 9 |
| Cloud Watch | 39 | 23 | 33 | 6 |
| *Hydrology* | | | | |
| Water Walk | 13 | 26 | 47 | 14 |
| Model Watershed | 7 | 27 | 46 | 20 |
| Practice Hydrology Protocols | 29 | 27 | 36 | 8 |
| pH Game | 12 | 27 | 51 | 10 |
| What Can Live Here? | 10 | 27 | 51 | 13 |
| Further Investigations Using GLOBE Data | 7 | 26 | 56 | 11 |
| *Land Cover/Biology* | | | | |
| Odyssey of the Eyes | 10 | 21 | 56 | 13 |
| Some Like It Hot | 5 | 22 | 61 | 12 |
| Discovery Area | 5 | 22 | 59 | 14 |
| Site Seeing | 8 | 26 | 53 | 13 |

[2] A $p < .05$ level of statistical significance means that there is less than a 1 in 20 chance that a difference this large or larger would be observed in samples of this size by chance if there were no real difference between the two populations from which the samples were drawn.

## Table 4.4 (continued)

| Activity | Implementation Plans | | | |
|---|---|---|---|---|
| | Have Implemented | Definitely Will Implement | Might Implement | Definitely Will Not Implement |
| *Land Cover/Biology (continued)* | | | | |
| Seasonal Changes at Site | 19 | 32 | 40 | 9 |
| Bird Classification | 9 | 26 | 50 | 15 |
| What's the Difference? | 3 | 21 | 60 | 16 |
| *Soil* | | | | |
| Soil and My Backyard | 7 | 19 | 53 | 22 |
| Field View of Soil | 5 | 21 | 51 | 23 |
| The Data Game | 2 | 19 | 56 | 24 |
| How Much Water Soil Holds | 6 | 24 | 49 | 21 |
| Soil—The Great Decomposer | 8 | 23 | 50 | 19 |
| *GPS* | | | | |
| Relative/Absolute Direction | 14 | 21 | 46 | 19 |
| Working with Angles | 14 | 20 | 44 | 23 |
| Offset GPS Measurements* | 11 | 19 | 48 | 23 |
| What is the Right Answer? | 7 | 20 | 53 | 20 |
| *Seasons* | | | | |
| Observing Seasonal Changes at Site | 26 | 34 | 33 | 7 |
| Students Ask Questions About the Seasons | 19 | 30 | 42 | 10 |
| What Should Your Students Investigate? | 12 | 28 | 50 | 10 |
| Using Graphs to Explore Annual Temperature Cycles | 23 | 31 | 40 | 6 |
| Select Another GLOBE School for Detailed Study | 8 | 24 | 52 | 16 |
| Prepare a Report on the Investigations | 8 | 27 | 52 | 13 |

Sample sizes: $300 \leq n \leq 334$.

* After the development and fielding of our survey, Offset GPS Measurements became a protocol in the 1997 Guide Supplement.

Note: The spring 1997 Teacher Survey and this table address those learning activities included in the 1996 Teacher's Guide. Additional learning activities were added to the program in summer 1997, after our survey was completed.

The rate of implementing GLOBE II learning activities, by and large, was not higher for those members of the sample who were trained with the GLOBE II materials than for those trained with GLOBE I. (Exceptions were the Thermometer Building, Water Walk, and Relative/Absolute Direction activities.) The time required to get the program up and running and the priority placed on collecting data appear to swamp any positive effect of having received training on more learning activities. At the same time, none of the learning activities had as high a proportion of teachers reporting that they "definitely will not implement" it as was found for a number of the data collection protocols. We speculate that this difference reflects teachers' lower familiarity with the learning activities.

Table 4.5 shows how well teachers feel the GLOBE training, Teacher's Guide, and other support materials prepared them to implement the GLOBE II learning activities in the various investigation areas, by time of training. In contrast to teachers' confidence about their preparation for implementing protocols (Table 4.3), the learning activity data generally show that teachers trained in June 1996 or later (i.e., with GLOBE II) are more likely to feel at least adequately prepared to implement the learning activities. The biggest difference is found for the Soil activities. Fifty-seven percent of those trained with GLOBE II feel at least adequately prepared to implement these activities, compared with 34% of those trained before June 1996.

## Bases for Selecting Protocols and Learning Activities

Lower-than-desired implementation rates for protocols and learning activities do not appear to be the result of a poorly prepared Teacher's Guide. The previously mentioned winter 1996-97 phone interviews provided teachers trained in GLOBE with the opportunity to rate the quality of the GLOBE II protocols and learning activities they had tried out with their students and to explain why they had chosen to implement these and not others. Quality ratings for those GLOBE II protocols and learning activities that teachers had administered were high: of those teachers who had tried a GLOBE II protocol with their students, an average of 92% said in the phone interview that the protocol had been easy to follow, and an average of 95% said they had been comfortable implementing it.

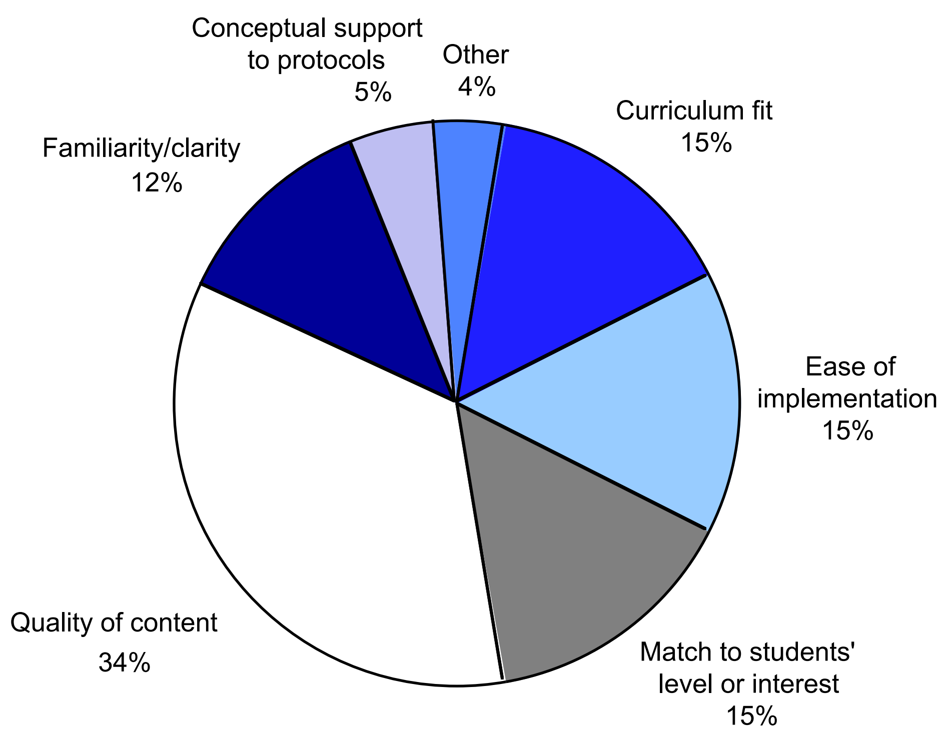
**Table 4.5**
**Teachers' Perception of Their Level of Preparation for Implementing GLOBE II Learning Activities (Percent)**

| Investigation Area and Training Time | Preparedness Rating | | | |
|---|---|---|---|---|
| | Fully Prepared | Adequately Prepared | Partially Prepared | Definitely Not Prepared |
| *Atmosphere Activities* | *39* | *36* | *2* | *4* |
| Pre-June '96 training | 41 | 33 | 23 | 3 |
| Post-June '96 training | 38 | 49 | 12 | 2 |
| *Hydrology Activities* | *26* | *36* | *30* | *7* |
| Pre-June '96 training | 27 | 35 | 32 | 7 |
| Post-June '96 training | 24 | 45 | 24 | 7 |
| *Land Cover/Biology Activities* | *22* | *36* | *35* | *8* |
| Pre-June '96 training | 23 | 34 | 36 | 8 |
| Post-June '96 training | 18 | 49 | 28 | 5 |
| *Soil Activities* | *11* | *26* | *36* | *26* |
| Pre-June '96 training | 11 | 23 | 39 | 27 |
| Post-June '96 training | 15 | 42 | 26 | 18 |
| *GPS Activities* | *26* | *37* | *26* | *12* |
| Pre-June '96 training | 26 | 35 | 29 | 10 |
| Post-June '96 training | 25 | 48 | 10 | 17 |
| *Seasons Activities* | *24* | *33* | *29* | *14* |
| Pre-June '96 training | 24 | 36 | 28 | 12 |
| Post-June '96 training | 26 | 23 | 33 | 18 |

Sample sizes: trained pre-June '96 = $247 \leq n \leq 268$; trained post-June '96 = $55 \leq n \leq 61$.

The reasons teachers cited (in response to open-ended questions) for choosing these protocols and activities were revealing. The most common type of justification centered around the quality of the content itself (e.g., "Really helped kids understand what remote sensing is." or simply, "Valuable.") Thirty-four percent of the selection rationales given were such justifications based on content. Next in prevalence were rationales based on the fit with the curriculum ("We were on meteorology."), those based on convenience or ease ("Could do these with the equipment that was available."), and those based on an assessment that the material was at the right level for the teacher's students or likely to be of interest to them ("Others are way over their heads."). Each of these types of rationale accounted for 15% of the responses. Next in frequency were rationales based on the familiarity or clarity of the protocol or learning activity ("We had worked on this before."), which accounted for 12% of responses. The remaining rationales concerned the extent of conceptual support for data collection activities (for learning activities) or more idiosyncratic circumstances ("Had to teach it at a workshop. Had to try it out beforehand."). Figure 4.2 summarizes our analysis of these responses.

**Figure 4.2**
**Reasons for Selecting Specific Protocols and Activities**




## Use of GLOBE Web Site Features

As described in Chapter 1, there were major improvements in the usability of various components of the GLOBE Web site and many features were added during school year 1996-97. The spring 1997 Teacher Survey respondents were asked whether they had used various components of the GLOBE Web site and, if so, how frequently. Table 4.6 shows their responses. In interpreting these data, it should be kept in mind that not all of the Web resources were designed for the same level of use; to take the Web chats as the extreme case, live participation was scheduled on just three distinct occasions (although users could later review an electronic record of the chats).

The most frequently used components of the GLOBE Web site appear to be the Student Data Archive, GLOBEMail, and the visualizations of student data. More than 75% of active teachers report having used these facilities at least occasionally. The lowest utilization rate was found for the Web chats (59% had not used them at all) and the Frequently Asked Questions (29% said they had not used them at all). In viewing these data, it should be remembered that Web chats are time dependent and therefore allow much less opportunity for use (for "live" participation) than ongoing features such as the Data Archive, GLOBEMail, and the visualizations.

**Table 4.6**
**Frequency of Use of GLOBE Web Site Features (Percent)**

| Features | Reported Frequency of Use | | | |
|---|---|---|---|---|
| | Once a Week or More | Occasionally | Once | Not at all |
| Visualizations of Student Data | 18 | 64 | 12 | 7 |
| Visualizations of Reference Data | 13 | 58 | 17 | 12 |
| Visualization Gallery | 11 | 51 | 15 | 23 |
| GLOBEMail | 25 | 53 | 10 | 12 |
| GLOBE Stars | 5 | 46 | 23 | 27 |
| GLOBE Student Data Archive | 22 | 58 | 13 | 7 |
| GLOBE Bulletin | 14 | 52 | 14 | 20 |
| Scientist Corner | 3 | 51 | 26 | 20 |
| Frequently Asked Questions | 2 | 39 | 30 | 29 |
| Web Chat | 1 | 19 | 21 | 59 |
| School Interaction | 7 | 57 | 16 | 20 |

Sample sizes: $300 \leq n \leq 334$.

On the positive side, most active GLOBE teachers use the main Web site features at least occasionally. But if one supposes that a truly intensive implementation of GLOBE would involve students in using the Student Data Archive and data visualizations once a week or more, this intensity is relatively infrequent. For the Student Data Archive, just 22% of teachers in the survey sample reported weekly use. The percentages for the student data visualizations and the reference data visualizations are 18% and 13%, respectively. The aspect of the GLOBE Web site most likely to be used at least once a week was GLOBEMail, which 25% of the teachers surveyed said was used at least once a week.

Looking beyond survey statistics, qualitative data suggest that GLOBE teachers became increasingly adept with using GLOBE Web resources during school year 1996-97. The GLOBE program established a Resource Room on the Web site, where teachers could find sample lessons developed by other teachers and descriptions and links for GLOBE-relevant Internet resources. Nancy Burton, a Colorado elementary school teacher who has been very active in GLOBE teacher training, agreed to head up a group of GLOBE teachers to review submissions from GLOBE classes and search out Internet sites to identify resources that GLOBE teachers could use. An example of the kind of material in the GLOBE Resource Room is the content posted in April 1997. In addition to hot links to Internet sites, the Room had five activity descriptions ("Classroom Suggestions") developed by GLOBE teachers and students. One activity, developed by teacher Bob Jost, documented the thinking and resources used by his 6th-grade class as they sought to check the reasonableness of a very high temperature reading they obtained from their site in Fresno, California. A GLOBE school in Finland contributed three data explorations. In one, they compared winter temperatures in Akutan, Alaska, with those in Devil's Lake, North Dakota, attempting to understand the factors besides latitude that affect temperature. In another activity, they compared readings from GLOBE schools in Finland, the Czech Republic, and Australia. In a final activity, they recorded snow temperature at ground level and two meters above the ground and related these temperatures to albedo. Nancy Burton's personal contribution to this section was an exploration of her GLOBE data compared with data for other sites, along with research topics suggested by the differences.

# Chapter 5. Implementation Models, Challenges, Strategies

In this chapter, we describe how GLOBE is being implemented in those schools with active programs, the challenges that teachers face in implementing GLOBE, and strategies that schools and teachers have developed for coping with those challenges.

## Grades and Classes Where GLOBE Is Implemented

Roughly 40% of the teachers in our survey sample reported working with elementary school students (generally kindergarten through grade 5); 60% were implementing GLOBE with middle or secondary school students (grade 6 and above). It should be noted, however, that these averages are dominated by U.S. teachers and that international programs have a quite different student profile. Among active international GLOBE teachers, only 9% teach at the elementary level. Hence, internationally, GLOBE students are older than those in the United States.

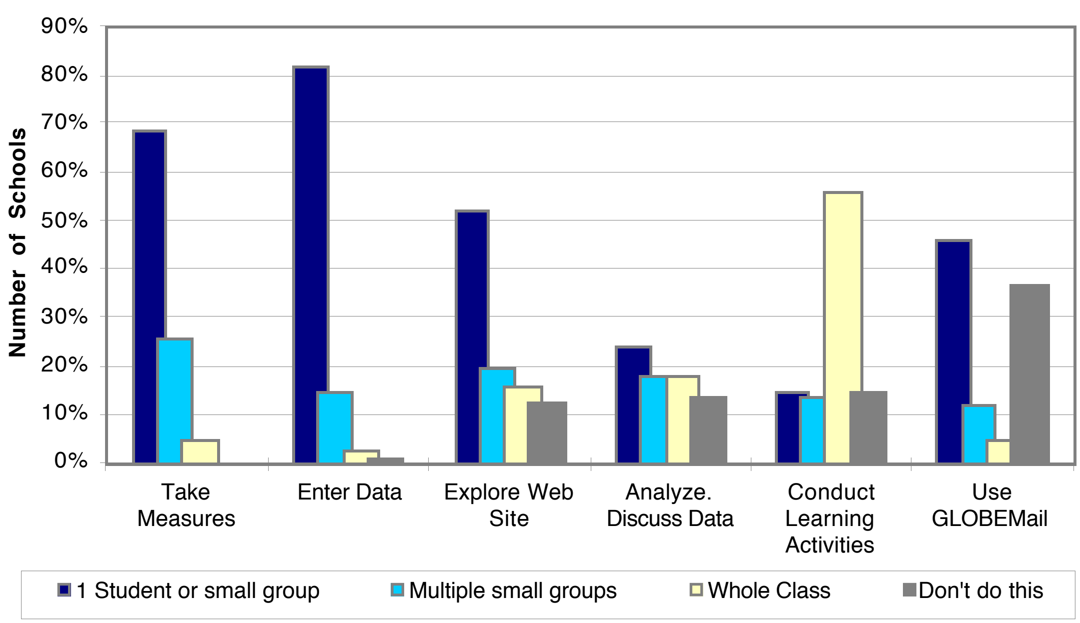
Of the active U.S. elementary GLOBE teachers, roughly one in four are elementary science specialists, teaching science to more than one class. These elementary science specialists are likely to have had more academic preparation in science than is typical among elementary teachers. The great majority of U.S. elementary GLOBE teachers, therefore, are elementary generalists. This fact has implications for their training and support. (Internationally, there were only six elementary teachers in our survey sample.)

When GLOBE is implemented at the middle or secondary level in the United States, it is usually (roughly in three cases out of four) within a regular class. Other forms of implementation at this level are a lunch group or club or a pull-out program, in which a few students are excused from their regular class to take part in GLOBE activities. The most frequently cited classes at the middle and upper school levels were environmental science, general science, and earth/space science. International teachers working with middle or secondary school students are about as likely to implement GLOBE within a club or pull-out program as they are to implement it within a regular class.

The size of the group that GLOBE teachers work with in their most active GLOBE class or club provides some indication of how their activities are organized. In grades kindergarten, 1, 2, or 3, GLOBE teachers typically work with 10 or fewer students on GLOBE activities. By grade 4, the modal group size is 21 to 30, the typical size for a whole class, and this pattern dominates through grade 7 in U.S. schools. (Internationally, teachers at these grades are more likely to work with 10 or fewer students.) Another shift occurs at grade 8, when teachers again report that their most active GLOBE group consists of 10 or fewer students, suggesting that GLOBE tends to get treated as an option for some portion of the class, rather than as part of the core curriculum. This tendency to work with smaller groups is particularly strong in grades 10-12, where 63%, 67%, and 60% of GLOBE teachers work with small groups.

Teachers were also asked directly about the way in which they organize their students for conducting different aspects of the GLOBE program. Figure 5.1 shows their responses. Taking GLOBE measurements, entering data on the computer, exploring information on the GLOBE Web site, and telecommunicating with other GLOBE schools are usually performed by a single student or one small group of students. A significant minority (26%), however, have multiple small groups take the measurements on any given day, a strategy many teachers like because it provides a check on data quality and an opportunity for students to confront issues such as measurement error, statistical outliers, and so on. In contrast, teachers reported that GLOBE learning activities are usually conducted as whole-class activities. No single organizational pattern dominates in analyzing and discussing GLOBE data.

**Figure 5.1**
**Organizational Structures for GLOBE Activities**



## Implementation Challenges and Strategies

The active GLOBE teachers in our survey sample were asked to rate the extent to which various aspects of GLOBE implementation had proved to be a challenge for them in school year 1996-97. The proportion of teachers finding each aspect a "major challenge" is shown in Table 5.1, alongside the proportions found in the spring 1996 survey of active teachers. These challenges themselves are described, along with strategies for coping with them, below.

**Table 5.1**
**Factors Active Teachers Rate as "Major Challenges" in Implementing GLOBE (Percent)**

| *Challenge* | *Spring 1996 Sample* | *Spring 1997 Sample* |
|---|---|---|
| Finding time for GLOBE, given other curriculum and testing requirements | 37 | 44 |
| Collecting data on weekends, vacations, etc.* | 44 | 64 |
| Fitting activities into school schedule | 35 | 41 |
| Finding time to prepare for implementing GLOBE | 31 | 37 |
| Getting to the data collection site | 20 | 20 |
| Getting access to adequate computers | 15 | 15 |
| Getting computer technical support | 10 | 9 |
| Logging onto GLOBE server | 12 | 5 |
| Assessing what students are learning from GLOBE | 19 | 18 |
| Integrating GLOBE with the rest of the curriculum | 18 | 20 |
| Securing GLOBE equipment | 18 | 20 |
| Finding funds to purchase scientific measurement instruments | 13 | 18 |
| Obtaining a phone line | NA | 14 |
| Finding appropriate activity for rest of class | NA | 11 |
| Obtaining an Internet service provider | NA | 11 |
| Presenting activities at right level for students | 11 | 10 |
| Obtaining support from administrators, other teachers | 11 | 10 |
| Obtaining a computer with modem | NA | 9 |
| Getting data collection instruments from the supplier | NA | 7 |
| Getting measurement equipment to work properly | 5 | 6 |
| Maintaining good student behavior during GLOBE activities | 4 | 6 |

Sample sizes: 1996 teachers, $230 \le n \le 244$; 1997 teachers, $294 \le n \le 340$

* Option wording was changed from "Accessing instruments for data collection on weekends, vacations" in 1996 to the less ambiguous "Collecting data on weekends, vacations, etc." in 1997.

### Continuous Data Collection

Science and schools operate in two very different time frames and with different goals and constraints. Scientific data collection calls for regularity and duration over time to produce a data set suitable for analysis and interpretation. If daily measurements are required, that means *every* day to a scientist. Schools, on the other hand, may have regular class schedules, but these are customarily altered or suspended for field trips, assemblies, and vacations. GLOBE teachers find themselves in the middle, trying to juggle the demands of science with those of school. Among teachers of active data-reporting classrooms, the biggest challenge GLOBE poses by far is the collection of data on weekends, vacations, and other times when school is not in regular session—64% of our survey sample cited this as a "major challenge." Nor does this challenge diminish with time. As Table 5.1 shows, the proportion of U.S. teachers citing it as a major challenge has increased, not diminished, since the 1996 survey.[1]

A strategy for addressing this challenge used at many GLOBE schools is the involvement of parents in the data collection. The W. G. Mallett School in Farmington, Maine, for example, involved 20 families in the collection of GLOBE data over the summer of 1996. The GLOBE teacher was able to report with some pride that no teacher was required to make an extra trip to the school over the summer in order to collect GLOBE data. Other schools have involved summer school staff, administrative staff, and scouting groups in keeping their data collection going over school vacations.

### Making Time for GLOBE

The next biggest set of challenges for GLOBE teachers all involve time, in one sense or another. Among spring 1997 survey respondents, finding time for GLOBE activities, given other curriculum and testing requirements was experienced as a major challenge by 44%. Only 14% thought this had been easy. Having time to complete GLOBE activities within the school's schedule constraints (e.g., trying to fit GLOBE activities into a lunch period) was reported as a major challenge by 41%. Both of these challenges reflect the limits to the amount of time teachers have with their students relative to the number of things teachers are charged with accomplishing with them. Teachers' own time is also a constraint. Thirty-seven percent of survey respondents said lack of time to prepare for GLOBE activities had been a major challenge.

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[1] We believe that at least some of this increase was caused by a slight change in the option wording from "Accessing instruments for data collection on weekends, vacations" to the less ambiguous "Collecting data on weekends, vacations, etc."

As the program has gained experience, it has become apparent that the lack of time to add major new components to class activities is a seriously limiting factor. Teachers consider it a challenge to find a place for GLOBE, not because it is incompatible with their curriculum but simply because there is not enough time to cover all their curriculum and testing requirements.

GLOBE teachers and administrators at the case study sites reported that GLOBE is highly congruent with the emphasis on *doing* rather than just learning science, as found in national and emerging state science standards documents. Where problems were more likely to emerge was at the local level, when national and state standards get translated into a required local curriculum. Several respondents in both our winter phone interviews and the spring teacher survey reported being less active in implementing GLOBE in 1996-97 than they had been in 1995-96 because a new science curriculum had been introduced locally and was receiving strong district emphasis. Four responses to open-ended survey items illustrate this problem:

> *In [state] our curriculum is very specific and predetermined. It leaves very little time to implement or infuse something like GLOBE, even though GLOBE is a wonderful activity. The related activities don't dovetail well with our[state] required labs.*
>
> *GLOBE is a reach in instruction. I wish we had time to do more GLOBE and less "specified" curriculum. But, so it goes.*
>
> *We are still trying to find the best way to align the GLOBE program to our district's increasingly specific student performance and content goals.*
>
> *I regret that I have yet to find a way to make GLOBE a regular part of our curriculum. I suspect that it may get more difficult as [state] and the nation move toward greater specificity in student outcomes. This will make it harder to justify time spent on activities and content that is not 100% aligned with the outcome standards as represented on unit, grade level, course, and graduation evaluations.*

It is ironic that while GLOBE is touted as an excellent embodiment of the science inquiry emphasis in national and many state science education standards, the implementation of standards-based reforms at the state and locals level is often producing pressure for covering so many specific topics that implementation of GLOBE is made more difficult.

At the middle and secondary school levels, having a separate class for GLOBE can help to reduce the press of some of these time-related challenges. Teachers who feel they can do full-fledged implementations of GLOBE usually work either in environmental or earth science classes or in settings where their science curriculum is not tightly constrained. When GLOBE is a central class activity rather than an enhancement or add-on, it is much easier to justify preparation time, as well as extended class time, devoted to GLOBE activities. At Waynesboro High School, in Waynesboro, Pennsylvania, for example, GLOBE is the centerpiece for an environmental studies course at the 9th-grade level and an environmental education course for 11th-and 12th-graders. These courses focus on weather and the environment, with rotating teams of three to four students each taking responsibility for one of the GLOBE protocols.

Block scheduling can help in implementing GLOBE because longer stretches of time are more compatible with hands-on activities, especially when students need to go to an off-campus study site, collect, analyze, and report their data. At Kingsburg High School, in Kingsburg, California, block scheduling provides longer time periods, and GLOBE is implemented in two biology classes that meet on alternate days. Block schedules can create complications, however, since the class in which GLOBE is incorporated may not meet every day, often requiring coordination across teachers or special arrangements for supervising student data collection on the “off” days.

If GLOBE is to be implemented in a nontrivial way (i.e., if large numbers of students are to be involved and if educational context is to be provided for taking measurements), it needs to fulfill what teachers deem to be essential learning goals (i.e., replace, not supplement, existing activities). In view of this challenge, GLOBE teacher trainer Barbara Diliegghio developed a form for teachers to fill out during their four days of training. As teachers are going through GLOBE training, they are asked to identify and document on the form things they are already teaching that could be better taught, or taught in a more engaging fashion, through GLOBE activities. The intent is for teachers to identify these areas while GLOBE content is fresh in their minds so that they will have a head start on curriculum integration through replacing units with GLOBE activities by the time they have completed their training.

It is important for the GLOBE program to understand the subject areas into which GLOBE gets introduced also in order to make reasonable decisions about what to include among the protocol and educational activity offerings. Teachers of high school chemistry bring a very different perspective (and different educational backgrounds) than do environmental science teachers. The GLOBE program may have to make some choices in terms of the grade levels and traditional curriculum areas it will focus on supporting.

### Logistics

Several logistical concerns continued to be challenges for a significant fraction of active GLOBE teachers. Chief among these were getting to the study site and keeping GLOBE equipment secure, both cited as major challenges by 20% of survey respondents. Of concern to fewer teachers were getting the data collection instruments from the supplier (7%) and getting the instruments to work (6%).

Getting to the study site is a problem for many hydrology sites, especially at the elementary and middle school levels. Schools can often arrange for buses for a few visits a year, but regular trips to a distant water site usually require volunteer parent drivers. Some schools have identified students who pass their water site on the way to school and asked them to take the water measurements. (This arrangement limits the number of students involved in taking samples, however.) One teacher reported using his prep period to escort a small group of students to the water site every Friday. Often there is a tradeoff between how intrinsically interesting the water site is and its distance from the school. The experience of many GLOBE teachers suggests an emphasis on proximity.

Vandalism continues to be a problem in some schools. Many schools have chosen to put a fence with a locked gate around their instrument shelter. Another, less obvious strategy for protecting GLOBE equipment is to make sure that the community knows about the program and how the equipment is used. Principal Phil Stovall at Lincoln Elementary in Kingsburg, California, reported that after they moved their weather station, fenced it, and started publicizing the GLOBE program at school assemblies and in local papers, they had no more vandalism problems.

### Curriculum Integration

Integrating GLOBE with their curriculum was rated as a major challenge by 20% of teachers overall. The relatively modest overall level of concern surrounding curriculum integration masks deeper problems at the secondary level (grades 10-12), where 31% of teachers described curriculum integration as a major challenge.

GLOBE activities can be related to many aspects of the curriculum; survey respondents cited combining GLOBE with curriculum topics ranging from weather and environmental science to art, social studies, and technology literacy. Exhibit 5.1 shows some of the ways teachers described fitting GLOBE into various subject areas on our teacher survey.

**Exhibit 5.1**
**GLOBE Teachers' Descriptions of Curriculum Integration**

*We have adopted an integrated science program for grades 6-7-8. This is based on science principles that are common to all science disciplines. The GLOBE program fits seamlessly with our principles, and it integrates vertically as principles are taught again on a higher level.*

*At the second and third grade level, the children study temperature. In second grade, weather is a module as well as studying clouds. In the third grade, our study of the desert and the extreme temperatures. . . and how temperature affects different habitats has been reinforced by GLOBE. . . . Fourth graders study the earth, soil, and moisture in foods. The addition of testing soil moisture coordinated nicely. . . The water cycle is studied at all grades, which was easy to tie into our observations at the weather station and the hydrology site.*

*GLOBE activities concerning the atmosphere are completed early in the school year as a unit of study to develop background as to the value of taking measurements and what they indicate. We monitor the local newspaper on a weekly basis and each student has a collection of articles that cover the global warming issue. . . During the winter storm pattern we use GLOBE data to track storms and develop an understanding of local weather patterns. . . A sixth-grade class did an acid rain unit and we provided storm data to them. . . [we do] spreadsheet and graphing on the computer to determine trends in the GLOBE measurements.*

*The hydrology and atmosphere investigations fit in by using them for reading and writing activities. The measurements fit into the math curriculum by using instruments to practice reading numbers and making sense of readings. . . We have used the data to make graphs and learn how to interpret graphs. All the activities sharpen observation skills and help kids work in small groups. We use GLOBEMail to learn about other cultures and share GLOBE activities.*

*I now teach all metric measures that are used in GLOBE solely through GLOBE experience. I used to teach them out of a math book. . . . [In] Social Studies, directions, latitude, longitude, and aerial photographs are all taught solely through the GLOBE experience.*

As discussed earlier in the context of time constraints, what appears to be most difficult is justifying the time spent on GLOBE activities within secondary school classes with more tightly constrained curriculum objectives. Those responsible for courses such as high school biology or chemistry feel that they can give less class time to GLOBE.

One strategy for getting around these difficulties is to enlist the participation of multiple classes in implementing GLOBE, so that each class can implement just the part that fits with its curriculum but across classes students have an in-depth exposure to the program. At Kingsburg High School, for example, GLOBE teacher Peggy Foletta has successfully integrated Atmosphere, Biometry/Biology, Soil, GPS, and Hydrology investigations into her biology, Earth science, and AP (Advanced Placement) biology classes. Biology classes take the measurements for part of the year, and then Earth science classes take on the responsibility later in the year. Kingsburg High's chemistry teacher has implemented the Hydrology unit with his regular classes and uses the soil characterization protocol with his AP class.

Foletta also leads a group of teachers who are working together to integrate aspects of GLOBE and their school's Kings River environmental study project into science, art, civics, language arts, history, and computer classes. (See Exhibits 5.2 and 5.3, "GLOBE in the High School" and a curriculum integration plan, both by Peggy Foletta.) Students from nonscience classes also take part in field trips to the GLOBE and river project hydrology and biometry sites and use their observations to create art, poetry, multimedia projects, essays, and research papers on environmental issues.

### Assessment

Another instructional issue GLOBE teachers are grappling with is the assessment of what students are learning through GLOBE. This was seen as a major challenge by 18% of GLOBE teachers overall and 31% of secondary school teachers. Often, it is difficult to assess what students are learning in collaborative hands-on science projects. When assessment does not occur, students may go through the activities while learning little about the concepts underlying the measurements and procedures (Barron et al., 1995). The second edition of the GLOBE Teacher's Guide provides suggestions for classroom activities through which student thinking can be assessed (e.g., journals, performances). What the guide does not provide is a set of criteria (i.e., a rubric or checklist) for assessing the developmental level of individual students' responses. It is left to the teacher to figure out what he or she should be looking for in student science journals or

**Exhibit 5.2**
**Sample Strategy for Spreading GLOBE Across the Curriculum**

# GLOBE in the High School

by

**Peggy Foletta**

Kingsburg High School
1900 18th St.
Kingsburg, California 93631
Tel: 209-891-1212, Fax: 209-897-7759
E-mail: pfolett@telis.org

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## Abstract

The GLOBE Program, an international environmental monitoring and science education program for students K-12, was the catalyst that captured the vision and imagination of a group of students and teachers from a small rural central California high school, Kingsburg High School, and brought with it an array of learning experiences beyond our expectations.

After being trained as a Lead Teacher in March, 1995, I came back to school with enthusiasm and my mind spinning with ideas. But how was I to introduce the program to our students? I knew from day one that I wanted this to be a part of each science class in our high school. This was a program that students could engage in throughout their high school science program and its impact had a better chance of affecting them in a variety of ways if they continued to be a part of it for three or four years. What I didn't realize then was how this program was going to affect the whole school, not just the science department, and beyond!

I wasn't sure how to go about implementing the program, so I took three approaches:

1. I introduced the GLOBE Program into my biology classes;
2. I invited interested students to my room at lunch to hear about the program, giving a brief description of it in the school bulletin so they had an idea of what the program was about; and
3. since I was just beginning to spear-head an integrated river study project of our local Kings River and had a group of interested teachers, I invited them to an afternoon meeting to discuss how GLOBE would fit into our project (with the added incentive of food and permission to miss an in-service speaker).

The river project teachers saw this program as a nucleus for our integrated project. This lead to a collaboration of science, computers, English, art, history, and civics classes, all studying our local river environment with different focuses. For our curriculum we chose to weave the theme of the river environment through as many of the units we taught as we could, without changing our overall curriculum, which at the high school level is somewhat inflexible. In our collaboration we also saw how some of he concepts and processes that we each teach overlap, so we integrated several projects between classes to streamline and reinforce our teaching. The results have exceeded all of our expectations!.

The teachers in the science department and volunteer students helped set up the weather station. Volunteers and members of my biology classes took over the weather readings, which became part of our study of biomes. Chemistry students began making hydrology readings and biology students set up and continue to monitor the biology site. Later the earth science classes started taking the weather readings and the analytical chemistry class started doing the soil analysis. We now have enough data in the archive, two years, so that all to these classes can now analyze it. Groups of high school students are also mentoring GLOBE students from the elementary schools. Kingsburg High School is a much different place from what is was two short years ago!

## Exhibit 5.3
## Kingsburg High School Curriculum Integration Plan

Year: 1995-96

Curriculum Integration Development WORKPLAN

| Procedures/Activities | Performance Outcomes | Responsible Persons | Completion Date |
|---|---|---|---|
| The team plans the integration of science, communications, art, social science, and technology. | A detailed time line and action plan will be developed. | All team members | July '95 |
| Biology classes study environmental issues, sampling and data collection protocols, and equipment usage in preparation for field studies. They learn to telecommunicate data to global environmental projects. Biology students conduct field studies at the river in the fall and the spring. They intepret and share the information. | Science students will have the required skills to assess the biodiversity of the area and conduct water quality tests. During the field study, data will be collected and recorded. After the data is analyzed, it will shared with global organizations. | Peggy Foletta and Jim Yates | Background & Ist field study: Oct. '95 2nd field study April '95 |
| Computers classes learn to use spreadsheets to analyze data, desktop publishing to prepare professionals brochures, and HyperStudio to prepare multimedia presentations. | Students will apply their computers skills by analyzing the river data and preparing the brochures and multimedia stacks. | Lela Nickell | Analysis: Nov. '95 Other: May 96 |
| History classes study the history of the river area including dam construction and farming vs. riparian river rights. They obtain oral histories from area residents. | In collaboration with English classes, students will interview local officials and residents of the area. | Dina Siebenaler and Pamela McGee | Nov. '95 |
| English students learn narrative writing by studying I-search paper structure, the interview process, and how to conduct and document research. | In collaboration with history classes, students will write a river history via resident narratives of the region. | Pamela McGee and Dina Siebenaler | Nov. '95 |
| Art students study basic visualization skills and drawing exercises in the areas of the basic elements of art, contour drawing, use of a view finder, and field sketching | Students will have the basic skills to do field sketches at the river and help layout brochures and HyperStudio stacks. | Nancy Gaseor | Jan. '96 |
| English students learn poetry writing by analyzing professional and student developed poems and studying the writing process. | During spring field studies, students will produce poetry which reflects new ways of looking at the world around them. | Pamela McGee | April 96 |
| Economist/civics students study opportunity cost and government responsibility towards farming and nature. | Students will write a critical summation examining the cultural, economic, and historical value of the area. | Dina Siebenaler | April '96 |
| All students work collaboratively in preparing final reports using river history, student writings and drawings, societal impact and responsibilities, results of water quality tests and biodiversity surveys. The published results will take the form of community service brochures, a booklet on river history and environment, and HyperStudio stacks. | All students involved will combine their efforts to produce and publish in various formats the history, environment, and personal reflections of the Kings River area. Publications will be shared with the community. | All team members | June '96 |

presentations and to try to figure out which incomplete understandings are actually progress toward an adequate scientific understanding and which are in fact misconceptions that will stand in the way of acquiring new knowledge.

Some GLOBE teachers have been working on designing assessments of what their students are learning. Use of science journals is fairly common. A more elaborate, multifaceted approach has been developed at the Crescent Elk Middle School in Crescent City, California. GLOBE activities are incorporated into a teacher-designed multidisciplinary project called Amateur Hydrologists Sleuthing Solutions: The Cougar Hydrology Company Project. During the course of this project, students maintain a journal, reflect on the connections between math and science, design a wastewater treatment plant, do artwork or photography documenting their field trip, graph and present their water quality data, and even prepare a haiku poem about their experience. Their GLOBE teacher, John Caldwell, has designed a rubric for scoring the students' performance in this project (see Exhibit 5.4).

### Adapting to Students' Level

Concern over presenting GLOBE material at an appropriate level was seen as a major challenge by only 10% of survey respondents overall, but this summary figure does not reveal the much higher rate of concern among primary grade (K-3) teachers, 26% of whom reported finding presentation of GLOBE concepts at the right level for their students a major challenge.

One of our case study sites, W. G. Mallett School, serves students in grades K-3. Teachers there have identified a number of commercially available resources that are designed for primary grade students and support GLOBE activities. For example, simple icons of a sun by itself, a sun with a few clouds, more clouds, and a totally cloud-covered square can be used in conjunction with teaching students to take cloud cover readings. Students in kindergarten classes have used these symbols to create bar graphs of cloud coverage in their location over time (see Exhibit 5.5). Exhibit 5.6 lists some of the commercially available resources used at W. G. Mallett.

Although secondary school teachers were not more likely than teachers as a whole to rate presenting GLOBE at the right level for their students as a major barrier, open-ended responses gave an indication of concern among some teachers. For example, one teacher wrote:

**Exhibit 5.4**
**Crescent Elk Hydrology Project Assessment Rubric**

## Amateur Hydrologist Sleuthing Solutions
## Final Assessment Rubric

| Components | EXEMPLARY | PROFICIENT | APPRENTICE | NOVICE | |
|---|---|---|---|---|---|
| Does student writing show an understanding of math/science concepts and their connection to $H_20$? | Writing exhibits extraordinary effort and understanding of math and science applications. | Writing is clear and precise, reflecting math and science ideas and applications | Writing reflects a partial under -standing of math and science ideas and applications | Writing doesn't reflect an understanding of math and science ideas and applications | 1 |
| Does the waste $H_20$ Treatment Plant design meet water volume and cost parameters? | Plant design shows creative application of concepts while meeting criteria. | Plant design is efficient and meets criteria. | Plant design indicates an understanding of task: design criteria not met. | Plant design aspects not addressed; little understanding of concepts. | 2 |
| Is student art work and expression which illustrates math and science in the context of water? | Art work is unique, has visual and emotional appeal while meeting specifications. | Art work is clean, topic related and meets size specifications. | Art work is related to the topic; disorderly or does not meet specifications. | Art work is incomplete; failure to address guidelines and specifications. | 3 |
| Does group work exhibit cooperative learning as defined by teacher observations and student reports? * | Teacher observe and students report shared leadership, re-responsibility for group project. | Teachers observe and students report active contributions to the group project. | Teachers observe and students report some contribution to the group project. | Teachers observe and students report minimal contribution to the group project. | 4 |
| Does group presentation demonstrate a clear understanding of water quality monitoring. | Data analyses/ explanation is accurate, com-plete, and valid; shows connection to real world. | Data analyses/ explanation (numeric or graphic), is accurate, com-pelt, and valid. | Data analyses/ explanation (numeric or graphic), is complete. in-accurate, invalid | Data analyses/ explanation (numeric or graphic) is incomplete or invalid | 5 |

**Weight factor:**
**1. 20% 2. 16% 3. 12% 4. 12% 5. 40%**

*Individual/group evaluation. Each member will do a self evaluation and their score will be averaged in with the group score.

*I would like more advanced activities for the high school student—we are planning an advanced placement course next year and we are very interested in taking GLOBE to a higher level.*

Thus, looking across the survey items, it appears that the GLOBE materials are perceived as most appropriate at the upper elementary and middle school levels. Teachers at both higher and lower grade levels feel that they need to do some adaptation and enrichment of GLOBE for their students.

**Exhibit 5.5**
**W. G. Mallett Adaptation of GLOBE Activity for Primary Grades**

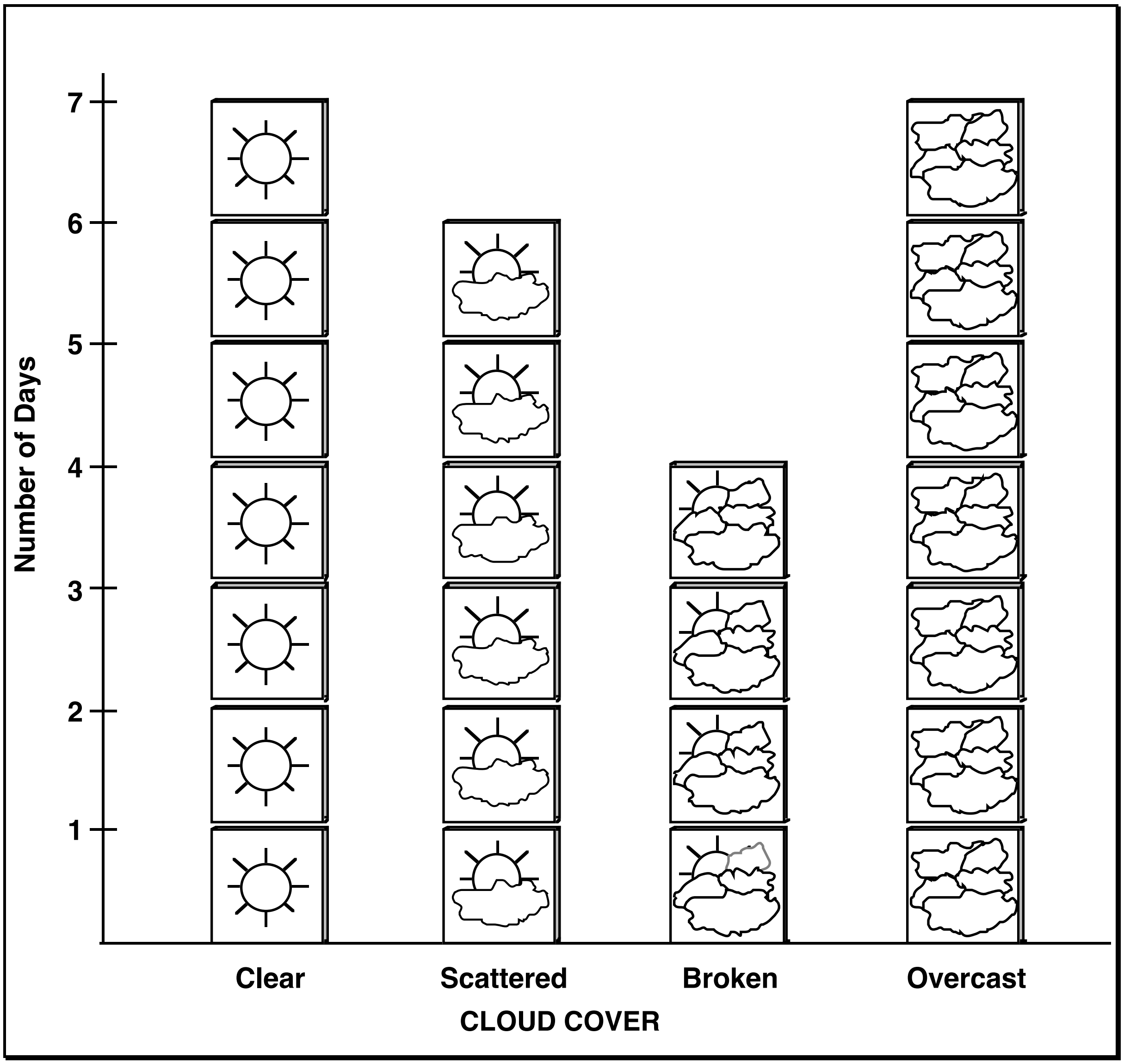


**Exhibit 5.6**
**GLOBE-Related Primary Materials Used at W. G. Mallett School**

*Can You Read a Map?* by Rozanne Lanczak Williams, Creative Teaching Press.

*How's the Weather?* by Rozanne Lanczak Williams, Creative Teaching Press.

*Questions and Answers About Weather,* by Jean Craig, Scholastic.

*Science with Weather*, by Rebecca Heddle and Paul Shipton, Usborne Science Activities.

*We Can Eat the Plants,* by Rozanne Lanczak Williams, Creative Teaching Press.

*Weather and Climate*, Step-by-Step Science Series for K-3, Carson-Dellosa Publishing Co.

*What's the Weather Like Today?* by Rozanne Lanczak Williams, Creative Teaching Press.

### Technology Access

In the evaluation of GLOBE's first full academic year of operation (see Means et al., 1996), we found that problems related to obtaining Internet access were the explanation given most frequently by teachers who had been trained by GLOBE but had not implemented the program with their students. Technology-related problems were a lesser but still significant issue for those who had implemented the program in school year 1995-96, and we sought to get more information in the spring 1997 survey concerning GLOBE teachers' access to technology and the challenges technology has posed for their implementation of GLOBE. In the newer survey, 15% of active GLOBE teachers reported that obtaining access to computers was a major challenge in school year 1996-97. Data from other portions of the survey help to illuminate the circumstances behind this number.

Over 99% of active GLOBE teachers reported having one or more computers in their classrooms. Most often (in 76% of cases), however, these teachers reported having just a single computer suitable for GLOBE in the classroom. Although the extent of Internet connectivity in schools is changing rapidly, relatively few classrooms have wide-area connections and local-area networks configured in a way that supports multiple computers in regular classrooms having simultaneous access to the Internet. Classroom technology access is supplemented in every active GLOBE school by potential access to computers in computer laboratories and/or library/media centers, but these resources must be shared and therefore require advance scheduling and are less likely to become a part of ongoing, intensive activity. At one of our case study schools, for example, there were two Internet-capable computers in the entire school in 1996-97, one in the GLOBE lead teacher's classroom and one in a conference room. When GLOBE teachers other than the lead teacher wanted to have some of their students enter GLOBE data or use the GLOBE Web site, they either had to interrupt the lead teacher's class or hope that no one had scheduled a parent conference, individualized testing, or band practice in the conference room.

One strategy GLOBE teachers are using to cope with limited access is to hook up their Internet-capable computer to a TV monitor so that larger numbers of students can view and discuss the GLOBE data visualizations at one time. Teachers can also download data sets from the Student Data Archive for analysis and display on computers without Internet connections. Another strategy is to have students compose their GLOBEMail messages on non-Internet-capable computers and then copy and paste them into GLOBEMail messages. This approach minimizes the amount of time each student spends on the Internet-capable computer. Some schools are giving students extra credit for taking on tasks such as keying GLOBEMail messages into a word processing program for other students.

Additional survey items attempted to get at the nature of the technology access challenge. Obtaining a phone line was reported as a major challenge by 14% of active GLOBE teachers, obtaining an Internet service provider by 11%, and obtaining a computer with modem by 9%. In addition to these technology start-up concerns, obtaining computer technical assistance was cited as a major challenge by 9%. It should be remembered that our sample consists of teachers who have been able to surmount GLOBE's technology challenges, at least for a significant part of the 1996-97 school year. We would expect all of these percentages to be higher in a survey of GLOBE teachers who are not active in submitting data through the World Wide Web. Logging onto the GLOBE server was reported as a major challenge by 5% of active teachers, down from 12% the prior year.

### Obtaining Support

Another category of challenge about which teachers were queried had to do with the challenge of obtaining the support they need. Finding funds to purchase the necessary scientific measurement equipment was seen as a major challenge by 18% of teachers. Obtaining support from administrators and other teachers was cited as a major challenge by 10%.

Many GLOBE teachers have been industrious in obtaining funds to support their program. Supplemental grants from districts, foundations, and local business were often used to purchase instruments or technology. Some schools were able to get Eisenhower funds to support teachers' time for GLOBE training.

### Classroom Management

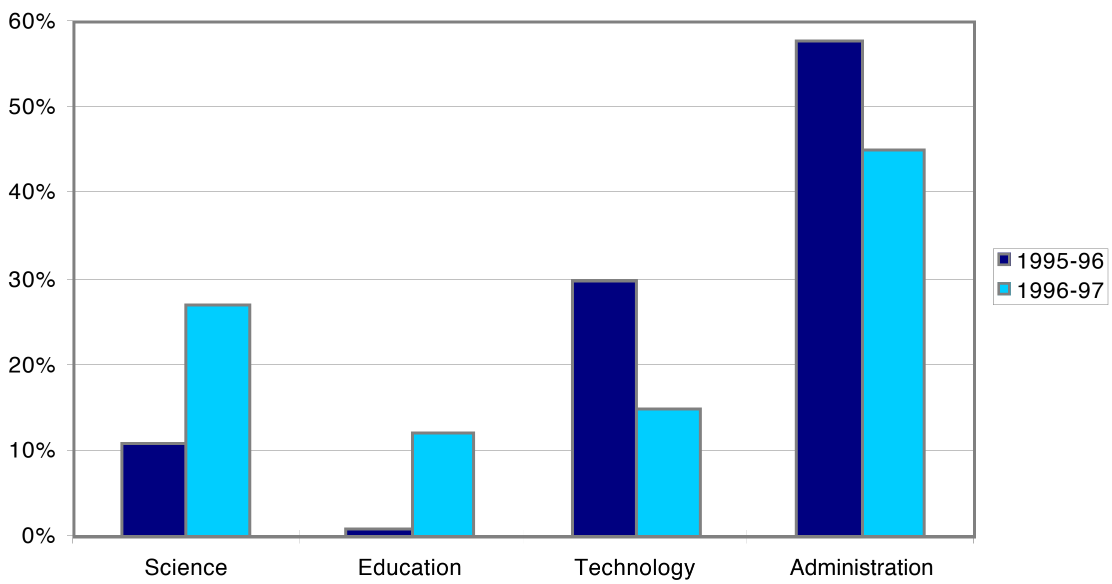
A category of challenges that posed relatively little concern to GLOBE teachers in the survey concerned management of their classrooms. Finding appropriate activities for the rest of their class while some students were conducting GLOBE activities was seen as a major challenge by just 11%. Maintaining good student behavior during GLOBE activities does not appear to be a significant problem; it was rated as a major challenge by only 6% of teachers.

Todd Toth, the GLOBE teacher at Waynesboro High School in Pennsylvania, has developed a system for efficiently organizing a wide range of GLOBE experiences for his students. He begins his course by providing students with a rationale for why the scientists need the data and then introduces the GLOBE protocols. He divides his class into teams of three or four and then teaches each team one of the protocols in depth. Following his instruction, each student team is responsible for teaching the other teams the protocol on which it has been trained. In this way, Todd himself teaches each protocol once, and his student teams are motivated to learn "their" protocol well enough that they can teach it to others. The student teams rotate each day so that over time they gain experience collecting all types of data.

## Inquiries of GLOBE'S Help Desk

The GLOBE program set up a Help Desk service at NASA Ames Research Center to assist teachers as they began to implement the GLOBE program at their schools. The Help Desk has maintained records of the number and types of queries received each month. These records provide converging evidence regarding the kinds of issues GLOBE teachers find most challenging. The total number of calls received from September 1996 to May 1997 was 2,960. Figure 5.2 shows a breakdown of these inquiries. Forty-six percent of the calls were classified as administrative, pertaining to matters such as training, the acquisition of GLOBE materials, and the acquisition of a school identification number; 27% of the inquiries were classified as science related since they were questions about instrumentation, data entry, and concerns regarding particular science content; 15% of the teachers' queries centered on technology-related issues, such as network applications, the Internet, or TCP/IP addresses; and 12% of queries were labeled education since they centered largely on educational activities or questions about pedagogy.

**Figure 5.2**
**Help Desk Inquiries, by Type, 1995-96 and 1996-97**




When we compare the types of help requested during Year 1 and Year 2 of the program, it is clear that teachers requested less administrative and technological support and asked more science-related and educational assistance questions in GLOBE's second year (see Figure 5.2). This is an indirect measure of teacher advances in mastering the technology, which at the same time suggests a need for additional clarification and supports for the science and educational aspects of the program.

## Building GLOBE Learning Communities

During 1997, the GLOBE program office articulated three ways in which the establishment of learning communities could enhance the program:

- Development of a “community of learners” within GLOBE schools through involvement of multiple teachers and classes.
- Involvement of multiple schools and extramural community members and groups in a given site’s implementation of GLOBE.
- Development of research communities of students, teachers, and scientists pursuing questions together regardless of their geographic dispersion.

In the next three sections, we examine available data showing where the program was with respect to these strategies at the time they were articulated. These data provide a baseline against which future progress can be measured.

### Spreading GLOBE within a School

Involving multiple teachers and classrooms in GLOBE has the potential advantages not only of spreading the labor involved but also of enhancing continuity and cohesion across science and mathematics instruction in different grade levels and classes.

> *Each of our three classroom teachers uses different aspects of the GLOBE Program to interface with their daily class work. The grade 4 teacher focused her investigations on water, using the various protocols to study the water in our school site wetland. One of our fifth-grade teachers integrates the various climate protocols with his energy unit. One of the fifth-grade teachers focuses her efforts on the land cover/biology protocols integrating this into her class study of plants and math. Our staff find GLOBE protocols help students understand the scientific method and gain a heightened appreciation of how data gathered daily can be used practically. We also use accumulated data for fifth-grade math graphing units.*

> *For years my Life Science classes have been studying the plants and animals in a riparian habitat on campus. This year we are following the GLOBE protocols and the students are elaborating on them by observing birds, insects, identifying plants, etc. The GLOBE work gives them more focus and they seem to be taking it more seriously because it will really be used. They are going to draw some conclusions from their data at the end of the year, trying to tie some of these things together. We have also been analyzing the water in the creek for the Department of Wildlife and now send this data into GLOBE for the hydrology data. The sixth grade does a weather unit so they collected the weather data at the start of the year and now a few seventh graders do it during their study hall. My eighth grade Earth Science class did some work with the satellite imagery as part of their astronomy unit and it*

*led into landforms and mapping. The eighth grade also does a lot of the hydrology work.*

Although there are individual cases of strong multi-teacher implementations, such as those described earlier in this chapter, most U.S. GLOBE programs continue to be run by a single teacher. In the spring 1997 survey, just 29% of active GLOBE teachers said that more than one teacher was involved in implementing GLOBE at their school, compared with 37% reported by a comparable group in the spring of 1996. However, there is some suggestion that the recent program policy of encouraging training of multiple teachers from a school is having some impact: of those teachers in the survey sample who were trained in June 1996 or later, 48% reported that one or more other teachers at their school were involved with GLOBE.

These teacher reports of multiple-teacher involvement are much higher than the official GLOBE program figures for the proportion of schools with more than one teacher trained by GLOBE or a GLOBE franchise. Fall 1997 data, for example, indicate that 82% of GLOBE schools have a single official GLOBE teacher.[2] The difference between the GLOBE training data and the teacher survey reports underscores the fact that GLOBE-trained teachers are in many cases taking responsibility for training and involving colleagues at their schools.

Such school-based training activities are not always easy, however, and our site visit data provide some insights into why GLOBE is difficult to spread within a school. When only a single teacher has received GLOBE training, the training of other teachers is a major undertaking. Often, the school will not have designated any paid teacher time for this activity, and the GLOBE teacher is left trying to recruit colleagues for training before and after school or over lunch. In addition to the exposure to scientists and experienced GLOBE teachers, off-site multi-day GLOBE training has the advantage of taking trainees out of their day-to-day environments and giving them the hours needed for sustained attention to learning the GLOBE protocols and learning activities and to planning their GLOBE implementation.

[2] Figures for multiple teachers were as follows: 14% of GLOBE schools with two officially trained teachers, 3% with three, and 2% with four or more.

### Implementation Models and Transitions

As the above discussion suggests, GLOBE is currently being implemented in a wide range of settings and with varying levels of involvement among school staff and communities. For the 1996-97 case study site visits, we chose GLOBE programs representing a range of implementation models and differing points of progress along the theoretical continuum from implementation by a single teacher within a single classroom to multi-class, multi-school implementation by a community of learners.

The *self-contained classroom* model is that used in schools where a single GLOBE teacher implements the program within the class that he or she teaches. The main advantage is the potential for students in the class to experience an intensive and in-depth coverage of the environmental science concepts related to the GLOBE protocols. This model has the potential for more curriculum integration and more time spent on GLOBE activities than with the *extracurricular activity model*, but limits GLOBE participation to those students who happen to be in the GLOBE teacher's class. In addition, as noted in the discussion of GLOBE implementation challenges above, this model leaves the entire burden for implementing GLOBE on the shoulders of a single teacher. Moreover, unless the teacher offers a special course designed around GLOBE, the amount of GLOBE that can be integrated with the course curriculum, given the time constraints of academic schedules, is likely to be limited at the middle and secondary school levels.

The *distributed-within-school* model involves having multiple teachers, working at different grades or in different subject areas, in joint implementation of GLOBE. This model can be thought of as a cooperative "jigsaw," with tasks and expertise distributed among several teachers within the school. Protocols can be implemented by particular grades or classes, as appropriate to their complexity and subject matter. This model facilitates involving a greater number of students in the program. It supports development and strengthening of linkages across grade levels and promotes collaboration and team teaching. In one variant of the model, teachers rotate responsibilities on a monthly or yearly basis, providing variety for both teachers and students and giving them an opportunity to gradually gain experience in the many aspects of the GLOBE program.

The *distributed-across-schools* model involves multiple schools in a cooperative implementation of GLOBE. The most common form for such programs appears to involve collaboration among schools in close proximity to each other that serve different grade levels (i.e., elementary, middle, and high schools). Protocols can be distributed across several different schools, or aspects of the program can be conducted by more than one school with provision for data comparison. There are many advantages to the multi-school model. First, schools are able to maintain and share their hydrology sites (as in Kingsburg, California). Second, the older students are able to serve as mentors for the younger students and can assist them while taking measurements, entering data into the computer, and browsing in the GLOBE Web site. Third, the work is distributed and shared across different classrooms and schools. Fourth, students can compare their results with each other. Finally, this type of implementation model promotes interschool collaboration and community building. The disadvantage of the multi-school model, and, to a lesser but still significant extent, the distributed within-school model is the amount of time that one or more teachers must devote to planning and coordinating joint activities. Schools and districts that provide recognition and support for this planning and coordinating time will be more likely to have sustained, successful distributed programs.

Exhibit 5.7 provides thumbnail sketches of our Year 2 case study sites, with emphasis on their implementation models.

### Involvement of Multiple Schools

As noted above, the teaming of multiple schools within close geographic proximity for GLOBE activities can have multiple advantages. If the schools collaborate to handle a single site, the involvement of a larger group of teachers and students increases the likelihood that a greater number of GLOBE protocols will get implemented. There is a broader group of participants to share the work. Where the schools are at different levels, increased opportunities for cross-age mentoring are provided and older students can help provide supervision and quality control for the activities of younger students, allowing young GLOBE students to do more with GLOBE than they would be likely to accomplish successfully on their own. When the schools each have their own sites and collect separate data sets, there is a good context for comparing data, which is very useful in helping to distinguish unusual but valid data readings from errors. These schools are likely to be familiar with each others' settings and they have a rich context for sharing and comparing data, discussing whether their readings are similar (in which case each provides the other with corroboration) or different (in which case there is the opportunity for a discussion of the various factors that might have produced the variation in readings).

**Exhibit 5.7**
**GLOBE Implementation at Five Sites**

### Springside School: A Distributed-within-School Program

This independent Philadelphia school serves a student body of approximately 460 girls from kindergarten through grade 12. Classes feature a student:teacher ratio of 15:1.

Scott Stein heads Springside's Science Division and is directing the implementation of the GLOBE program. Scott and one other teacher were trained by GLOBE. Scott decided to distribute the GLOBE protocols across five teachers (including himself) and six grade levels. His design for distributing GLOBE investigations is as follows:

| | |
|---|---|
| Atmosphere | Grades 3, 4, and 5 |
| Land Cover/Biology | Grade 5 |
| MUC | Biology 9 & 10 |
| Hydrology | Biology 9 & 10, Environmental Science 7 |
| Soil | Environmental Science 7 |
| GPS | All grade levels |

Scott chose to implement GLOBE in this manner because he believed that distributing the work among his colleagues would increase the probability that the entire program could be implemented. He also felt that different protocols were better suited for different grades' curricula.

### W. G. Mallett School: A Distributed Program at the Primary Level

W. G. Mallett is a K-3 elementary school that serves approximately 475 students from a small-town and rural population, which includes students from families of faculty members at the nearby state university.

Cynthia Stevens, the lead teacher at W. G. Mallett, is the only one of the school's teachers to have participated in training provided by the GLOBE program. Cynthia has trained four other K-3 teachers in aspects of GLOBE, however, with the result that five teachers are involved in implementing GLOBE across the four grade levels served by the school. The GLOBE investigations are rotated across classes on a monthly basis. Parents and faculty members from the nearby university are supporting the school's implementation of GLOBE. Many classroom activities focus on giving Mallett's young students the conceptual underpinnings for understanding GLOBE measurements rather than on data collection activities per se. Mallett students have been making atmosphere and GLOBE I hydrology readings and have begun working in the land cover/biology area.

### Kingsburg High School, Rafer Johnson Junior High School, Roosevelt Middle School, and Lincoln Elementary School: A Distributed-across-Schools Model

These four Kingsburg, California, schools have been collaborating on their implementation of the GLOBE program. Their collaboration emerged when Kingsburg High School teacher Peggy Foletta suggested a joint grant proposal to the GLOBE office. She proposed implementing the GLOBE program in coordination with teachers from the junior high, middle, and elementary schools in the same town as her high school. The schools received an equipment grant from GLOBE, and one teacher from each school was trained.

Following her own training by GLOBE, Peggy Foletta trained three other teachers in her high school, and together they handle most of the hydrology, atmosphere, and soil measurements. In addition, they have assisted Lincoln Elementary with their hydrology measurements. Shirley Esau, the GLOBE-trained teacher at Lincoln Elementary, conducted the atmosphere and GPS protocols with her 4th grade students. Richard Ross is the GLOBE-trained teacher at Rafer Johnson Junior High School. In the past year, his 8th-grade students implemented the atmosphere, hydrology, and biometry protocols. This year, they collected and entered their atmospheric data. Steve Hofer, the GLOBE-trained teacher at Roosevelt Middle School, had his 6th-grade students work with the older students from the high school to conduct their biometry measurements. Steve and his students have also collected atmospheric, hydrology, and GPS data.

### Waynesboro High School: A Self-Contained GLOBE Class

Located in a rural area in western Pennsylvania, Waynesboro High School serves approximately 1,400 students from four boroughs. Todd Toth is the GLOBE-trained teacher. He teaches an environmental education course to 11th- and 12th-grade students of varying abilities. Many of the students enroll in his course because they need a science credit to fulfill their graduate requirements. Other, more advanced students enroll in his course because it is considered one of the most interesting science courses offered in the school.

Seven years ago, Todd was asked to manage a fully automated weather station, which he incorporated into his environmental studies curriculum. Todd found that the GLOBE program fit very well with his existing curriculum and interest in the weather. He viewed the GLOBE program as a way to expand his curriculum. Student teams in Todd’s class take GLOBE measurements on a daily basis and discuss the patterns of results each week. They also visit their biometry sites twice a year.

### Crescent Elk Middle School: A Program in Transition

Crescent Elk is an example of a school in transition from a self-contained program model with a single GLOBE teacher to a distributed-within-school model. Like many of the other schools, Crescent Elk began with one GLOBE-trained teacher. However, because that teacher, John Caldwell, team teaches his science curriculum with mathematics teacher Chris York, a second teacher became involved. Another teacher, Patty Brunsing, is expected to be trained by GLOBE and will begin to implement the program with her students in the fall of 1997.

John teaches over 130 7th-grade students in interdisciplinary math-science blocks. Each Friday, John takes a group of students to the hydrology site, which is located in a nearby park, to conduct their measurements. John integrates the hydrology and soil protocols with a unit that he teaches on the environment. John and Chris have designed an integrated math and science unit called "Amateur Hydrologists Sleuthing Solutions," which requires students to conduct additional investigations involving mathematics in the context of hydrology. John also teaches 8th-grade students who conduct soil measurements while they work on a unit on oceanography.

John has recently formed a partnership with GLOBE teacher Peggy Foletta at Kingsburg High School. Their students have been corresponding over e-mail. John and Peggy urge their students to compare the data at their two sites, taking into consideration the geographic differences between their locations, the geology, and weather patterns.

An additional benefit of multi-school approaches is the enhanced likelihood of building a learning community with critical mass. One teacher's report of how the program has caught on in her district illustrates the advantages of broader-based programs:

> *Our district has sent 10 elementary teachers to training in the last two years. We—the trained teachers—have rewritten our hands-on science curriculum to integrate with GLOBE and make GLOBE . . . core. We will be training all the other fourth-grade teachers in the district this summer in our "newly integrated GLOBE curriculum." Parents districtwide have made the demand that all fourth-grade children have the opportunities that our "plot or trained" teachers and classrooms had. We will be training with four classrooms next year and about 110 students in my building will be doing GLOBE. . . . This program for me has put the push and drive of success back into my classroom.*

Top-down or district-initiated efforts to spread programs do not always work, however, as illustrated by the experience of this district science coordinator:

*While I trained a teacher at every level, K-5, in GLOBE in the summer of '96, all but one were not able to find the time to use GLOBE much beyond the basic introductions.*

One of GLOBE's strengths is the strong grassroots support it enjoys among teachers who have gone through GLOBE training. The creation of agreements with districts, through explicit training franchises or simply district support for adoption, can strengthen the program and provide significant supports to implementation. However, it is important to preserve the strong grassroots teacher commitment that GLOBE has engendered. Research on earlier educational innovations suggests that purely "top-down" implementation strategies are rarely successful (Berman & McLaughlin, 1978). The program's goal is to develop an infrastructure where teachers get more direct support, not to spread GLOBE as widely as possible through administrative fiat.

An example of a multi-school implementation is in Kingsburg, California, where teachers from four schools (high school, junior high, middle, and elementary), led by high school teacher Peggy Foletta, collaborated on submitting applications to GLOBE and were all trained during the spring or summer of 1995. In addition to implementing GLOBE at their own schools, these four teachers later led a GLOBE training session at California State University at Fresno for local teachers and have also led in-service days on GLOBE.

Students from Kingsburg High School have mentored students from the other three schools, helping them with learning to take measurements at the hydrology and biometry sites, and assisting them with data entry and understanding the uses of the GLOBE Web site and visualizations. Students interviewed in focus groups in the elementary schools are looking forward to staying involved in GLOBE as they progress to junior high and high school. Parents, the local community, and the local school district view the program as an opportunity for their students to be a part of an important international project, to interact with students from different countries, and to become part of a global community while maintaining their rural quality of life.

Although the Kingsburg collaboration appears to be one of the strongest multi-school programs, some measure of interschool involvement in implementing GLOBE appears to be fairly common. Twenty-six percent of GLOBE schools report that they are working with other schools in their district. There is no sign of a trend toward increased local collaboration, however; this percentage is the same as that reported in the spring of 1996.

### Community Involvement

Another strategy for building up a community of individuals to support a local GLOBE program is to involve parents and local agencies, businesses, and academic institutions in supporting GLOBE activities. These individuals and organizations can help supply equipment, scientific expertise, transportation, and enthusiasm for sustaining and improving the program. Write-in responses to survey questions and examples found at the case study sites document some of the ways in which GLOBE schools are enlisting local assistance.

The W. G. Mallett school in Farmington, Maine, for example, involves parents and their local university in their K-3 GLOBE program. As described above, parents were a major factor in the school's ability to continue data collection through the summer of 1996: 20 families volunteered to take GLOBE measurements for specified time periods. The school's principal reported that GLOBE measurement taking is an excellent way to involve parents in their children's education: the task is well specified, and it is something parents and children can do together. During the school year, parent volunteers make it possible for small groups of young students to have adult supervision while leaving the classroom to input data or do research using the GLOBE Web pages.

The same school is developing a collaboration with the University of Maine at Farmington centered around the GLOBE program. Initially, the university's involvement was strictly informal and ad hoc; a number of faculty members had children in the GLOBE lead teacher's class and volunteered to assist with GLOBE. More recently, the lead teacher (Cynthia Stevens) and several faculty members in the university's natural sciences department have been working on a broader relationship. University staff and students were heavily involved in running "stations" with GLOBE-related activities for an Earth Day 1997 GLOBE round robin. In addition, the faculty members are in the process of seeking approval from their department to start sending students to Mallett on a regular basis to support the science program and GLOBE activities there. The university plans to begin with the science majors, who bring the most science expertise, and then to involve the science education students (for whom this would be an important practical experience).

A fairly common form of community involvement is the use of student-collected GLOBE weather data by local television and radio stations. GLOBE students at Waynesboro High School in Pennsylvania provide their readings to the local newspaper. Over time, the GLOBE students have achieved a reputation as a source of localized weather data. For example, a local construction company called the school and asked whether the students could send them their precipitation data for a particular period of time during the past year. The company was threatened with a lawsuit for not completing a construction contract on time, and they needed some data to support their claim that there had been an unusual amount of rain during that period. The students submitted a summary report of the amount of rainfall, and the company continues to receive a monthly summary from the GLOBE students. Exhibit 5.8 highlights another example of how this GLOBE class has become a knowledge resource concerning local environmental conditions for the community.

### Building Research Communities

Because education's ultimate purpose is to prepare students for life outside of school, there is value in providing students with experiences working in geographically distributed research groups. When students from distant GLOBE schools team up to jointly investigate selected topics, their collaboration parallels the working relationships of professional scientists. The Internet provides the medium through which schools miles apart can share their conjectures, data, and interpretations.

**Exhibit 5.8**
**Local Uses of GLOBE Data**

A few weeks into the semester, one of Waynesboro High School's GLOBE student teams returned to class with a pH level reading from a nearby stream that was extremely low. At first, their teacher, Todd Toth, thought that the measure was wrong because for the past few weeks the readings had been higher. After school, Todd took the readings himself and realized that the students were correct. During that same week there was an article in the local newspaper about the fire station having a gas odor problem. The fire company learned about the pH level study being conducted at the high school and asked to see their data. A week later, a fireman contacted the students and asked them to conduct a 2-week study because an EPA representative was coming and wanted to see the local data. In the end, they discovered that the tanks from a local gas station were leaking. The students were "proud of the fact that they were able to find this—that they were right about the data and that the EPA wanted their data." This story made the local newspaper.

One example of this type of collaboration occurred between two of our case study schools, which are located in different parts of California. John Caldwell and Chris York, two teachers at Crescent Elk Middle School, and Peggy Foletta, a teacher at

Kingsburg High School, decided to initiate collaborative research among their students. Students were encouraged to exchange e-mail messages regarding their hydrology sites and to inform each other of any differences in their weather patterns. The teachers hoped that their ongoing communication would eventually lead students to consider geographic differences between schools in addition to geology and time of year as they constructed explanations for weather pattern differences. Excerpts from students' e-mail messages suggest a focus on the exchange of basic information during the early phase of this collaboration:

> *In Crescent City it is mostly cold yet there are days it is sunny. It is very foggy here too, but not foggy enough to have a foggy day schedules. In science we are studying acid rain it is very exciting... This winter there were many mud slides and floods. Our hydrology site is a creek. The creek is called Elk Creek. We also have a weather site outside of our school. Our science teacher's name is John Caldwell. He's the best! .....In this class you have to be very hands on and not afraid to do new things or you will not make it. Everyday we get on the radio and tell the forecast.* —Crescent Elk Group 1

> *A couple of weeks ago we went to Elk Creek and we had some new water tests. The water tests we run are: DO test, pH, Turbidity, Alkalinity, Conductivity, Nitrates, Temperature, Coliform, Phosphates and Salinity. We are going back to Elk Creek this Friday if it is not raining.* —Crescent Elk Group 2

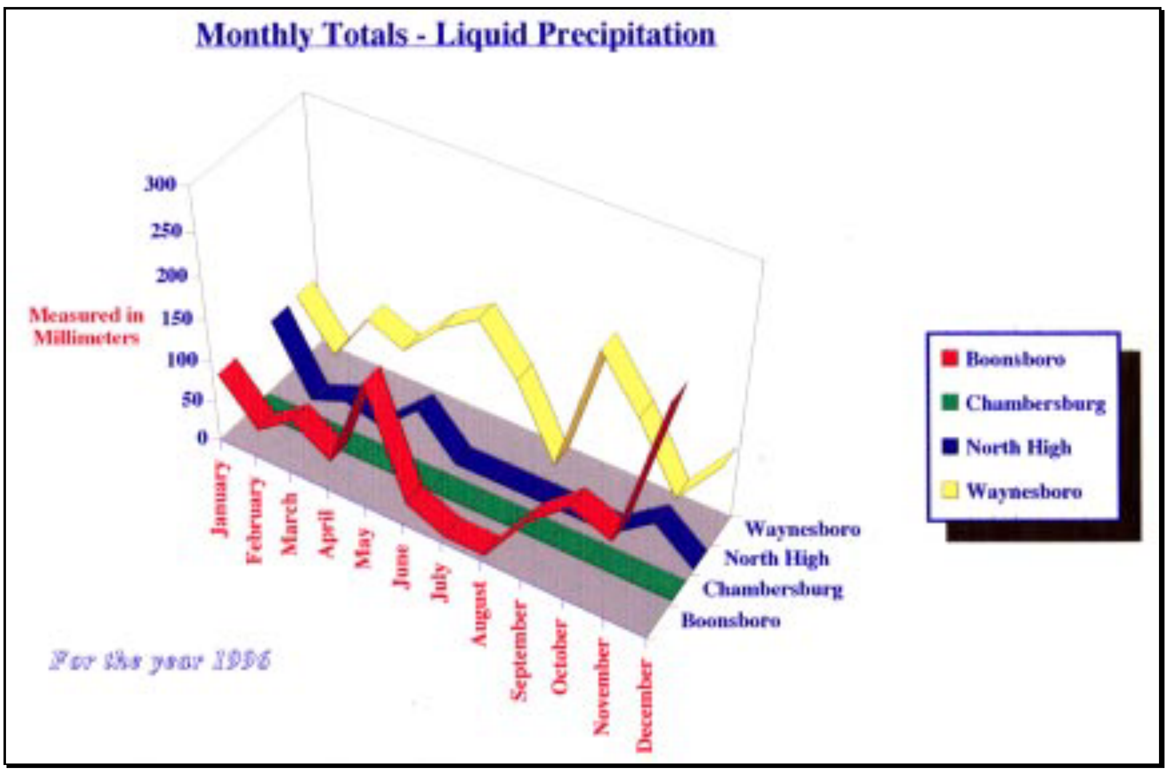
> *How does the abiotic factors (rainfall, sunlight) in your area affect your life style? What kind of plant and animal variation are present in your environment? What biome are you in?* —Kingsburg Group 12

Students in Waynesboro High School in Pennsylvania were involved in another kind of research analysis across schools. GLOBE program staff encouraged Waynesboro students to compare their GLOBE data with data of three other schools in their general area. In this case, the comparisons were viewed as one way to assess the accuracy of the school-collected data. The students developed a plan for which data to compare and how to analyze them. Students became familiar with the GLOBE Web site and the procedure for downloading data from the Student Data Archive. They abstracted 12 months of data from the archive for four schools for the variables Air Temperature, Water Temperature, Precipitation, pH, and Solid Precipitation. Students graphed the data (see Exhibit 5.9), conducted data analyses, and wrote a report with their findings. An excerpt from their report reveals their emerging interpretive skills:

> *Again, only three schools were involved in this category [liquid precipitation] due to Chambersburg's lack of data. After analyzing the data in this category students came to the conclusion that Waynesboro data was similar to Boonsboro data but did not compare with North High's at all. Possibly due to both Waynesboro and Boonsboro being close to a mountain which would influence our precipitation totals. Summer time data was excluded this time due to no data to compare to our own.* —Waynesboro environmental studies class report

At the end of their report, the students reflected on this experience: "Waynesboro students were able to see how difficult data analysis can be and what types and quantities of data are needed to ensure accurate results."

**Exhibit 5.9**
**Waynesboro Students' Graph of Liquid Precipitation Data**




In addition to forming research groups with other schools, some GLOBE classes have benefited from active collaborations with the GLOBE scientists. In many cases, these collaborations were formed as scientists were in the process of developing and field testing new data collection protocols and associated learning activities. Through collaborating with scientists, students are not only exposed to additional information, but also provided with role models and a window into the nature of conversations and rules of evidence and argumentation within the scientific community.

This kind of student-scientist collaboration occurred at our case study school in Waynesboro, Pennsylvania. Dr. Dan Rodier, a GLOBE principal investigator, was conducting research on UV radiation and asked the students in Todd Toth's environmental studies class whether they would be interested in collecting UV radiation measurements throughout the year. After several conversations and e-mail exchanges with Dr. Rodier, Todd Toth and his students became very excited about their chance to be a part of Rodier's UV radiation research. The students monitored the UV radiation, cloud type, and cloud coverage each week and then compared their results with those found in Washington, D.C. Weekly results were sent to the GLOBE office. The students also presented their findings, along with suggested actions to prevent overexposure to UV radiation, to other students in their school. Rodier spent a great deal of time explaining all of the procedures to the students and described the ways in which he was using the data and the UV scale. As the project unfolded, he spent time answering student inquiries. Toth stated that the students became very involved in the UV study because they saw how their data were being used.

Another way in which GLOBE schools can collaborate on experiments with each other and with GLOBE scientists is by getting involved in the suggested activities presented on the GLOBE Web page. For instance, in the fall of 1997, the GLOBE Chief Scientist, Dr. Dixon Butler, invited students to participate in an experiment on El Niño. The Web site presents information, visualizations, and suggested activities for student participation. In this way, students from all over the world can trace the patterns of El Niño, test hypotheses, and make predictions that build on the data already collected.

All of these collaborative activities help facilitate and sustain research communities within the larger GLOBE program. Within these smaller communities, distant collaborators can support each other's efforts to design and carry out original investigations and data analyses and can provide an authentic audience for each other's work. Moreover, interactions within the research community provide a truer picture of the nature of scientific collaboration than students are likely to obtain from any textbook.

# Chapter 6. Effects on Teachers and Students

## GLOBE's Influence on What Teachers Teach

Science teaching in the United States has been criticized for emphasizing vocabulary and verbal definitions of concepts drawn from a broad range of content areas rather than focusing on "big ideas" and their use in reasoning and solving problems in multiple contexts. Blue ribbon panels examining the U.S. science education curriculum have criticized its "layer cake" approach, which treats science domains such as biology and chemistry as discrete disciplines to be covered in one year with no return to that domain to deepen a student's understanding of it. Further, the curriculum has been criticized as "a mile wide and an inch deep," characterized by the disconnected teaching of many vocabulary items and facts independent of exposure to any realistic context within which they can be used (TIMSS, 1996). In the words of the American Association for the Advancement of Science's Project 2061:

> *If we want students to learn science, mathematics, and technology well, we must radically reduce the sheer amount of material now being covered. The overstuffed curriculum places a premium on the ability to commit terms, algorithms, and generalizations to short-term memory and impedes acquisition of understanding.* (1993, pp. xi-xii)

In its publication *National Science Education Standards* (1996), the National Research Council (NRC) called on teachers to implement inquiry-based science education programs within which students "describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others" (p. 2). In organizing its recommendations concerning the science content considered critical for all students, the NRC included topics in physical science, life science, earth and space science, and the history and nature of science that can be found in GLOBE as well as in other inquiry-oriented science education programs and curricula.

The GLOBE program's philosophy has always been one of providing resources and leaving decisions concerning curriculum and pedagogy to individual teachers and their local administrations. Nevertheless, the design of the GLOBE program embodies a number of features that are valued in the education reform and the mathematics and science standards communities. The entire program is based on the premise that it is valuable to have students engage in doing real science investigations, rather than in reading about the products of science investigations or watching or mimicking demonstrations. In addition, by their nature, authentic science investigations are most conveniently carried out by small groups, fitting in with the emphasis in many education quarters on collaborative learning. Network technology and the use of external experts and resources are two other essential components of the program that fit in with the kinds of changes many educational critics advocate. Thus, although it is not an explicit GLOBE program goal to change what or how teachers teach, such issues are important from an education policy perspective.

In Chapter 2, we described the recruitment of 44 GLOBE classes containing 4th-, 7th-, or 10th-graders to participate in the GLOBE student assessment, along with 27 classes of students whose teachers had applied for but not yet completed their GLOBE training at the time of the assessment. To provide a context for interpreting the student assessment data (to be described below), we asked each teacher of one of these classes to complete a matrix showing which GLOBE-related topics (expressed in common terminology rather than using proper names from the GLOBE materials) they had taught in the class to be assessed. For those topics they had covered, teachers were asked to indicate what students had been expected to do within that topic area: (1) learn vocabulary and concepts, (2) observe and measure, (3) apply concepts, or (4) analyze and compare data.

Table 6.1 shows the topic areas and the performance expectations reported by GLOBE and non-GLOBE teachers whose classes were in our student assessment samples. Not surprisingly, some of the earth science topics were taught by larger proportions of GLOBE teachers than of non-GLOBE teachers. GLOBE teachers were significantly more likely to have covered 4 of the 13 topics—earth's atmosphere, air temperature, precipitation/evaporation/condensation, and cloud types and weather. None of the topics was significantly more likely to have been taught by non-GLOBE teachers.

Whereas it might be expected that GLOBE teachers would be more likely than non-GLOBE teachers to cover content areas related to earth science, what is more impressive is the different pattern of performance expectations in the GLOBE and non-GLOBE science classes. Non-GLOBE teachers were significantly more likely than GLOBE teachers to have taught vocabulary and concepts to the exclusion of any of the higher

**Table 6.1**
**Topic Areas and Performance Expectation Percentages of GLOBE and Non-GLOBE Teachers Whose Students Were Surveyed in Spring 1997**

| Topic Area | Have Not Covered | | Have Learned Vocabulary/ Concepts | | Have Made Observations/ Measurements | | Have Applied Concepts | | Have Analyzed/ Compared Data | |
|---|---|---|---|---|---|---|---|---|---|---|
| | GLOBE | Non-GLOBE | GLOBE | Non-GLOBE | GLOBE | Non-GLOBE | GLOBE | Non-GLOBE | GLOBE | Non-GLOBE |
| Earth's atmosphere | 16 | 67** | 14 | 30^ | 50** | 15 | 18 | 11 | 21* | 4 |
| Air temperature | 2 | 41** | 4 | 26* | 57 | 62 | 24 | 24 | 27^ | 11 |
| Precip./evap./conden. | 7 | 37** | 6 | 52** | 60* | 30 | 23 | 22 | 26 | 15 |
| Clouds/types of weather | 4 | 81** | 6 | 19 | 62** | 11 | 19 | 7 | 26* | 7 |
| Water cycle | 28 | 22 | 22 | 59** | 24 | 19 | 22 | 19 | 13 | 11 |
| Water quality indicators | 33 | 56^ | 22 | 26 | 24 | 15 | 11 | 7 | 11 | 19 |
| Plant growth/function | 40 | 52 | 4 | 30* | 34^ | 15 | 19 | 19 | 6 | 15 |
| Species identification | 42 | 62^ | 15 | 19 | 38^ | 19 | 6 | 8 | 4 | 4 |
| Soil generation | 77 | 73 | 6 | 27* | 11* | 0 | 4 | 0 | 2 | 0 |
| Soil properties | 74 | 81 | 4 | 12 | 17 | 12 | 4 | 4 | 4 | 0 |
| Earth shape/movement | 35 | 46 | 35 | 54 | 13 | 4 | 13 | 8 | 8 | 4 |
| Seasons | 29 | 46 | 31 | 50 | 13 | 8 | 23** | 4 | 10 | 12 |
| Maps/latitude/long | 26 | 46^ | 19 | 38^ | 31 | 23 | 11* | 0 | 15** | 0 |

* $p < .05$ for difference between GLOBE and non-GLOBE classes.
** $p < .01$ for difference between GLOBE and non-GLOBE classes.
^ Marginally significant $p < .10$ for difference etc.

performance levels in 3 of the 13 topic areas ($p < .05$) and were marginally more likely to have done so ($p < .10$) in another two. In no case did the probability of GLOBE teachers' teaching only vocabulary and concepts exceed that of non-GLOBE teachers. GLOBE teachers were significantly more likely than non-GLOBE teachers to require one or more of the higher-level tasks (collecting data, applying concepts, or analyzing data) in 9 of the 13 topic areas ($p < .05$). In no topic area were non-GLOBE teachers more likely to have given their students tasks at one of the higher levels.

### Student Reports of Classroom Activities

A second set of data pertinent to GLOBE's influence on what and how teachers teach is the responses of students in the GLOBE and non-GLOBE classes to questions about the activities they perform while studying science. Student reports corroborate teacher reports in suggesting that, compared with their age peers in non-GLOBE classes, GLOBE students spend less science instruction time learning vocabulary and answering questions about science. At all three grade levels, GLOBE students were significantly more likely than non-GLOBE students to say that they work in a group with other students and use a computer (see Table 6.2). At two of the three grade levels, GLOBE students were also more likely to say they help other students learn and do something to improve the environment around their school or community most or all of the time. In contrast, non-GLOBE students at all three grade levels were significantly more likely than GLOBE students to report answering questions from a book or worksheets most or all of the time, and non-GLOBE 4th- and 7th-graders were more likely to report spending science class time on learning new words most or all of the time. Non-GLOBE students were also more likely to report that they write about what they have learned most or all of the time. This difference may reflect, in part, the limited emphasis many GLOBE classes have placed on preparing written descriptions of GLOBE work. It is likely, however, that it also reflects students' interpretation of the survey item as including the kind of brief written responses called for by worksheets and end-of-chapter questions, which are more commonly used in non-GLOBE classes.

For other activities, either there were no differences between the groups of students, or patterns were inconsistent across grade levels. For example, among 4th-graders, marginally more non-GLOBE students than GLOBE students reported "using my head to figure out a problem" most or all of the time ($p < .10$) whereas among 10th-graders, the relationship was reversed, with more GLOBE students than non-GLOBE students reporting using "my own ideas to solve a problem" most or all of the time ($p < .05$). There was no significant difference among groups of seventh-graders.

**Table 6.2**
**Students' Reports of What They Do "Most of the Time or Always" in GLOBE versus non-GLOBE Science Classes**

| | *Percent of Students Reporting* | | | | | |
|---|---|---|---|---|---|---|
| | *4th Grade* | | *7th Grade* | | *10th Grade* | |
| ***Activity*** | ***GLOBE*** | ***Non-GLOBE*** | ***GLOBE*** | ***Non-GLOBE*** | ***GLOBE*** | ***Non-GLOBE*** |
| Work in a group with other students | 55* | 46 | 58** | 33 | 52** | 27 |
| Use a computer | 49** | 10 | 29** | 12 | 42** | 5 |
| Help other students learn | 26** | 14 | 14 | 15 | 23** | 9 |
| Do something to improve the environment around my school or community | 20 | 28* | 14^ | 10 | 15** | 6 |
| Use my head to figure out something/Use my own idea to solve a problem | 59 | 67^ | 22 | 19 | 23** | 13 |
| Learn how to do something important/Work on a real-life problem that I care about | 52 | 53 | 12 | 10 | 11 | 10 |
| Write about what I have learned | 15 | 40** | 9 | 23** | 20** | 15 |
| Answer questions from a book or worksheet | 22 | 30* | 20 | 34** | 15 | 34** |
| Learn new words | 40 | 61** | 26 | 40** | 27 | 27 |
| Talk to my parents or other adults about what we're doing in science | 23 | 36** | 18 | 15 | 7 | 7 |
| Get mixed up about what I am supposed to do | 8 | 5 | 8 | 10 | 7 | 9 |
| Get bored doing something I don't care about | 16 | 15 | 20 | 23 | 24 | 26 |

* $p < .05$ for chi-square on choices of "Most of the Time or Always" vs. "Fairly Often," "Sometimes," or "Never/Almost Never."
** $p < .01$ for chi-square on choices of "Most of the Time or Always" vs. "Fairly Often," "Sometimes," or "Never/Almost Never."
^ Marginally significant $p < .10$ for chi-square on choices of "Most of the Time or Always" vs. "Fairly Often," "Sometimes," or "Never/Almost Never."

## What Students Like about GLOBE

GLOBE students continue to exhibit a high degree of enthusiasm about this program. Students were asked to respond to a broad set of attitudinal statements concerning GLOBE. Fourth-graders marked each statement as "true" or "false"; 7th- and 10th-graders rated a similar set of statements on a five-point scale from "strongly agree" to "strongly disagree." Tables 6.3 and 6.4 present the responses for the three grade levels.

If we treat "strongly agree" or "agree" responses on the part of 7th- and 10th-graders as the equivalent of 4th-graders' marking "true," 95% of 4th-graders and 71% of 7th- and 10th-graders indicated that they like doing GLOBE activities in general. Working with other students contributed greatly to these positive feelings; 91% of 4th-graders, 79% of 7th-graders, and 77% of 10th-graders indicated that this made GLOBE more fun.

In addition, students have a sense that the project is important. Ninety-three percent of 4th-graders and 73% of 7th- and 10th-graders said that they think the GLOBE project will help people better understand the Earth. Most students feel that the measurements

**Table 6.3**
**Fourth-Graders' Attitudes toward GLOBE**

| *Statement Regarding GLOBE* | *Percent Responding "True"* |
|---|---|
| I like doing GLOBE activities. | 95 |
| Working with other students makes GLOBE more fun. | 91 |
| GLOBE has taught me how to do more things with computers. | 60 |
| It gets boring taking the same measurements over and over. | 28 |
| I think the GLOBE project will help people understand the earth better. | 93 |
| I don't know why we take the measurements we do for GLOBE. | 13 |
| The measurements my class takes are important for scientists. | 91 |

Sample sizes: $339 \leq n \leq 372$

**Table 6.4**
**Seventh- and Tenth-Graders' Attitudes toward GLOBE (Percent)**

| *Statement Regarding GLOBE* | *Strongly Agree* | *Agree* | *Neither* | *Disagree* | *Strongly Disagree* |
|---|---|---|---|---|---|
| I like doing GLOBE activities. | 31 | 40 | 22 | 3 | 4 |
| Working with other students makes GLOBE more fun. | 44 | 35 | 17 | 2 | 2 |
| GLOBE has taught me how to do more things with computers. | 16 | 20 | 35 | 14 | 15 |
| It gets boring taking the same measurements over and over. | 20 | 17 | 31 | 19 | 13 |
| I think the GLOBE project will help people understand the earth better. | 36 | 36 | 21 | 4 | 3 |
| I don't know why we take the measurements we do for GLOBE. | 7 | 7 | 22 | 29 | 35 |
| The measurements my class takes are important for scientists. | 29 | 37 | 25 | 5 | 4 |

Sample sizes: 379 ≤ n ≤ 386

they take are important for scientists (91%, 65%, and 67%, respectively). Only small proportions of students reported that they do not know why they are taking the measurements they do (13%, 14%, and 14%). These proportions are very similar to those in the spring 1996 student survey.

Students were also asked how much they liked four specific GLOBE activities: (1) taking measurements, (2) putting GLOBE data on the computer, (3) looking at satellite pictures, and (4) looking at GLOBE data collected by students in other places. As in the 1996 survey, among 4th-graders the most popular of these activities was putting data on the computer, with 76% of students saying that they liked it "a lot" (see Table 6.5). Taking measurements and looking at satellite pictures were not far behind with 69% and 63% of 4th-graders, respectively, reporting that they liked doing them "a lot." Looking at GLOBE data collected by other students was slightly less popular; nevertheless, almost half of the 4th-graders said that they liked doing this "a lot."

Secondary students were generally less likely to say they liked anything "a lot," and their preference ranking of GLOBE activities was slightly different. The activity that these students rated the highest was using visualization software to look at satellite images (60% of 7th-graders and 47% of 10th-graders like "a lot"), followed by putting GLOBE data on the computer (52% and 32%), taking measurements (41% and 29%), and looking

**Table 6.5**
**Extent to Which Students Like Various Aspects of GLOBE (Percent)**

| ***Aspect of GLOBE*** | ***4th-Graders*** | | | ***7th-Graders*** | | | ***10th-Graders*** | | |
|---|---|---|---|---|---|---|---|---|---|
| | ***Like a Lot*** | ***Like a Little*** | ***Do Not Like*** | ***Like a Lot*** | ***Like a Little*** | ***Do Not Like*** | ***Like a Lot*** | ***Like a Little*** | ***Do Not Like*** |
| Taking measurements | 69 | 28 | 3 | 41 | 47 | 12 | 29 | 50 | 21 |
| Putting GLOBE data on computer | 76 | 19 | 5 | 52 | 35 | 13 | 32 | 46 | 22 |
| Looking at satellite pictures | 63 | 31 | 6 | 60 | 33 | 7 | 47 | 46 | 7 |
| Looking at GLOBE data collected by students in other places | 43 | 44 | 13 | 33 | 49 | 18 | 22 | 60 | 18 |

Sample sizes: 4th grade, $244 \le n \le 388$
7th grade, $163 \le n \le 228$
10th grade, $92 \le n \le 150$

at GLOBE data collected by students in other places (33% and 22%).

### Teacher Perceptions of What Students Learn

When asked about the extent to which their students had acquired various types of skills through their GLOBE experiences, teachers overall reported the greatest gains in the areas of observational skills, measurement skills, and technology skills. Sixty-nine percent reported that their students' observational skills had increased "very much," 68% for measurement skills, and 60% for technology skills (see Table 6.6).

**Table 6.6**
**Teacher Perceptions of How Much Student Skills Increased with GLOBE**

| | *Percent of Teachers* | | | |
|---|---|---|---|---|
| ***Skill Area*** | ***Very Much*** | ***Somewhat*** | ***Not Very Much*** | ***Not at All*** |
| Observational skills | 69 | 30 | 1 | 0 |
| Measurement skills | 68 | 30 | 2 | 0 |
| Technology skills | 60 | 34 | 6 | <1 |
| Ability to understand data | 51 | 46 | 3 | <1 |
| Ability to work in small groups | 52 | 43 | 5 | <1 |
| Critical-thinking skills | 36 | 50 | 13 | 2 |
| Map skills | 30 | 51 | 16 | 3 |
| Ability to regulate own learning | 28 | 52 | 17 | 3 |
| English language skills | 16 | 47 | 25 | 12 |

Sample sizes: $303 \leq n \leq 339$

Teachers were also asked to rate the magnitude of GLOBE's impact on their students' knowledge in eight content areas. The largest perceived gain was in knowledge about atmosphere (74% thought their students' knowledge had increased "very much"), followed by Internet science resources (56%) and GPS (40%). Table 6.7 displays teachers' perceptions of GLOBE's impact on their students' level of knowledge.

More detailed descriptions of what students gain through GLOBE were obtained through on-site teacher interviews. Waynesboro High School GLOBE teacher Todd Toth, for example, reported that the introduction of GLOBE resulted in marked increases in his students' awareness of their local surroundings. His students began acquiring basic knowledge about the topography of the land around them. Todd also believes that the GLOBE program has opened his students' minds to problems about the environment. At a more local level, students are becoming more interested in and knowledgeable about the quality of their farmland, the nearby streams, and the quality of their water.

**Table 6.7**
**Teacher Perceptions of How Much Student Content Knowledge Increased with GLOBE**

| | *Percent of Teachers* | | | |
|---|---|---|---|---|
| **Knowledge Area** | ***Very Much*** | ***Somewhat*** | ***Not Very Much*** | ***Not at All*** |
| Atmosphere | 74 | 24 | 1 | 1 |
| Internet science resources | 56 | 33 | 9 | 2 |
| GPS | 40 | 38 | 13 | 9 |
| Land Cover | 35 | 43 | 14 | 8 |
| Hydrology | 31 | 44 | 15 | 10 |
| Seasons | 31 | 48 | 15 | 6 |
| Geography | 23 | 57 | 15 | 5 |
| Soil | 13 | 28 | 26 | 32 |

Sample sizes: $250 \leq n \leq 336$

## Student Assessment Results

As described in Chapter 2, 777 GLOBE and 676 non-GLOBE students from 76 classes were given assessment items tapping (1) their knowledge of how to conduct GLOBE measurements, (2) their ability to recognize sound measurement and sampling practices, and (3) their ability to interpret data and apply earth science concepts. All non-GLOBE students were in classes whose teachers had signed up to take the GLOBE training (and hence were likely to be the same kinds of teachers as those leading GLOBE classes).

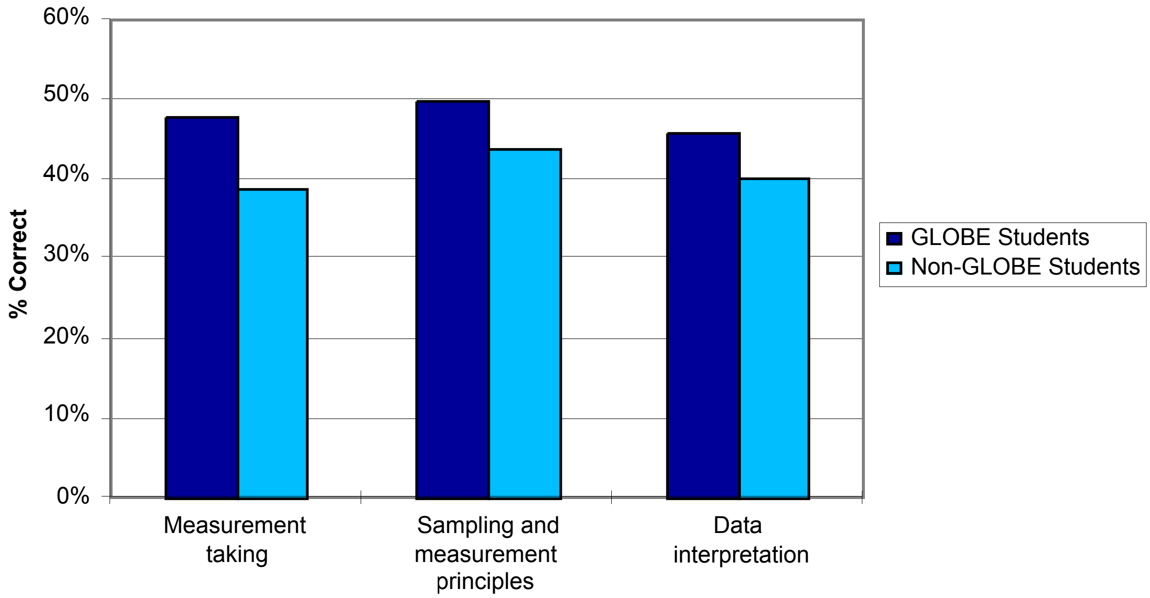
Fourth-graders in our student assessment sample received one of four assessment forms, each comprising 15 items from our item pool. The 4th-grade forms each contained 5 or 6 items on GLOBE measurements, 2 or 3 on sampling and measurement principles, and 7 on data interpretation. Seventh- and 10th-graders received one of four separate 20-item forms designed for their level. These contained 6 to 8 items on GLOBE measurements, 4 to 6 on sampling and measurement principles, and 7 or 8 on data interpretation.

We expected GLOBE students to show an advantage on GLOBE measurement procedures, at least in those investigation areas where their class had been conducting the protocols. It was less clear for the other two item types whether GLOBE students would outperform their grade-level peers in non-GLOBE science classes.

*GLOBE students vs. non-GLOBE students*. For each student, the proportion of correct responses (counting skipped items as incorrect) was calculated for the entire form and for each of the three item types. Overall, GLOBE students outperformed their non-GLOBE peers on the instrument as a whole (with a mean of 48% correct versus 41%) and on all three item types (see Figure 6.1). On items measuring ability to take measurements, GLOBE students averaged 48% correct, compared with 39% for other students ($p < .01$). For items tapping ability to identify steps congruent with sound sampling and measurement principles, GLOBE students averaged 50% correct compared, with 44% correct for non-GLOBE students ($p < .01$). For the items demonstrating ability to interpret data and apply concepts, the GLOBE mean was 46% correct, compared with 40% ($p < .01$). Significant differences were found for all three item types also when the analyses were performed on class means, rather than individual student means.

GLOBE students' superior performance on items that involve taking measurements is reassuring, but not surprising. What is more exciting news is the fact that GLOBE students appear to show an advantage also for less literal content, which is not uniformly taught in GLOBE—application of sampling and measurement principles and interpretation of data. These items were designed to tap deeper understanding of principles such as control of variables and sample selection, the ability to read data presented in tabular or graphic form, and the ability to use important environmental science concepts in making sense of data.

**Figure 6.1**
**Performance on Student Assessment Items by GLOBE Participation**




*Classroom coverage and student performance*. The findings just presented give less than a complete picture, however, because they fail to take into account the fact that many students—both GLOBE students and non-GLOBE students—had not received instruction on many topic areas covered by the test, and the number of areas varied across teachers. Thus, differences between the two groups could be an artifact of differences in classroom coverage.

Fortunately, the Classroom Information Sheets completed by teachers provided information on the areas each class had covered (e.g., precipitation, erosion) and what students had been expected to do in that topic area (learn vocabulary and concepts, take measures or observations, etc.). Thus, by matching particular student test items with the corresponding study areas on the Classroom Information Sheets, we were able to examine the relationship between content coverage/class performance expectations and student test scores on the three types of GLOBE assessment items.

Not surprisingly, students in classrooms that had covered the environmental science areas related to GLOBE assessment items performed better on items concerning measurement procedures and on items requiring identification of sound measurement practices within these content areas. Furthermore, in general, as teachers required more of students along our dimension of performance expectations (from learning vocabulary and concepts through applying concepts and interpreting data), students showed better performance on the assessment items related to taking measurements.

Asking students to learn vocabulary and concepts in the relevant content areas appears to boost performance on identifying steps congruent with sound measurement and sampling procedures, but not on the other types of items (see Table 6.8). Requiring students to take observations or make measurements appears to have modest positive effects on their ability to answer assessment items about measurement procedures, as one would expect, and appears to positively influence ability to recognize measurement practices that help ensure data quality. There is no apparent impact on the ability to interpret data and apply concepts, however. Asking students to apply concepts and/or interpret data appears to have modest positive effects on students' knowledge of measurement procedures, as well as their ability to identify steps congruent with sound measurement and sampling principles.

The one exception to the association between performance expectations and student performance concerns the test items requiring data interpretation and concept application. It is puzzling that students whose teachers expected them to apply concepts and/or interpret data did not perform better on these test items. A closer look at the data found that the exception to the expected pattern resulted not so much from *low* scores of students in classrooms whose teachers had high performance expectations as from unexpectedly *high* scores on the part of GLOBE students whose teachers said they had not covered a content area or had required their students only to learn vocabulary and concepts (50% correct and 45% correct, respectively). These data suggest that the data interpretation items on the GLOBE assessment are not tightly dependent on instruction in a specific content area.

*GLOBE students vs. non-GLOBE students, taking coverage into account*. If we equated GLOBE and non-GLOBE classes *completely* in terms of the content covered and what students did in that content area, there would be little reason to expect to see performance differences. On the other hand, the data reported in Figure 6.1 do not reflect any attempt to take into consideration differences between the two sets of students in terms of opportunity to learn. A stricter test of GLOBE's impact is a comparison of GLOBE and non-GLOBE students' performance on items related to content that was covered in their class in some way. To conduct this test, we excluded from our analyses data on assessment items for which students in a given class had not been exposed to relevant content. GLOBE and non-GLOBE students were then compared within each grade level in terms of performance on the three item types.

**Table 6.8**
**Relationship between Classroom Coverage and Student Performance, by Item Type (Mean Percent Correct)**

| *Classroom Coverage/ Performance Expectation* | *Item Type* | | |
|---|---|---|---|
| | *Taking Measurements* | *Sampling and Measurement Principles* | *Interpreting Data & Applying Concepts* |
| None | 42 | 36 | 46 |
| Learn vocabulary and Concepts | 43 | 43 | 45 |
| Make observations or measurements | 48 | 52 | 45 |
| Apply concepts | 51 | 55 | 43 |
| Interpret data | 51 | 59 | 41 |

When opportunity to learn is taken into account in this fashion, GLOBE students outperformed their non-GLOBE counterparts, as shown in Table 6.9. In fact, these differences are more pronounced than those depicted in Figure 6.1 (which did not take classroom coverage into account.) At the 4th-grade level, GLOBE students demonstrated strikingly better knowledge of GLOBE measurement procedures, scoring 52% correct, on average, compared with 29% for students from non-GLOBE classes. GLOBE 4th-graders also excelled in their ability to select options associated with sound measurement and sampling principles, 59% correct versus 50%, and in their ability to interpret data and apply earth science concepts, 49% versus 43% (the latter difference attained only marginal statistical significance, however, at $p < .10$). Differences among groups of 7th-graders followed similar patterns: 52% versus 40% for GLOBE measurement procedures, 51% versus 46% for sampling and measurement principles; and 42% versus 36% for data interpretation and inference.

**Table 6.9**
**Comparison of GLOBE and Non-GLOBE Students' Assessment Performance, by Grade Level**
**(Mean Percent Correct)**

| ***GLOBE Status and Grade*** | ***Item Type*** | | |
|---|---|---|---|
| | ***Measurement Taking*** | ***Sampling and Measurement Principles*** | ***Data Interpretation*** |
| *All Grades* | | | |
| GLOBE students | 53 ** | 56 * | 48 ** |
| Non-GLOBE students | 36 | 51 | 42 |
| *Fourth Grade* | | | |
| GLOBE students | 52 ** | 59 * | 49 ^ |
| Non-GLOBE students | 29 | 50 | 43 |
| *Seventh Grade* | | | |
| GLOBE students | 52 ** | 51 | 42 * |
| Non-GLOBE students | 40 | 46 | 36 |
| *Tenth Grade* | | | |
| GLOBE students | 55 ** | 59 | 54 |
| Non-GLOBE students | 35 | 59 | 48 |

* $p < .05$ for t-test between GLOBE and non-GLOBE students.
** $p < .01$ for t-test between GLOBE and non-GLOBE students.
^ Marginally significant $p < .10$ for t-test between GLOBE and non-GLOBE students.

Among 10th-graders, GLOBE students did significantly better than non-GLOBE students only on items concerning knowledge of measurement procedures, with a mean of 55% correct versus 35% correct. The advantage of GLOBE 10th-graders on their ability to interpret data and apply concepts was in the expected direction, 54% correct versus 48%, but fell short of statistical significance with the smaller sample available at the 10th grade. There was no difference between GLOBE and non-GLOBE students at the 10th-grade level on the items tapping ability to apply sampling and measurement principles (both scoring 59% correct).

Taken as a whole, the assessment data are very encouraging. After GLOBE's second year of operation, there is evidence of enhanced science and mathematics learning in classrooms where GLOBE is being implemented.

## Students' Concepts of Science

Learning theorists argue that an important aspect of science learning is the process of becoming socialized into a professional community (Hawkins & Pea, 1987). This socialization process entails knowing the community's standards of explanation and modes of discourse, as well as understanding the essential activities within the community. Most classroom science instruction divorces science learning from actual scientific practice, and tends to focus rather mechanistically on an idealized presentation of the "scientific method." This method is often presented to the students as a set of steps to be performed (e.g., observing, stating a hypothesis, making predictions, conducting experiments). As a result, many students infer that science consists only of those actions performed in a set order, and the social nature of science—the communication and back-and-forth wrestling with ideas, evidence, and alternative explanations—is not represented.

GLOBE students and those in the non-GLOBE comparison classes were asked what they thought scientists spend their time doing. As Table 6.10 illustrates, GLOBE students as well as their non-GLOBE peers identified the "traditional" actions that scientists perform (e.g., collecting data or planning experiments) as things scientists would spend "a lot" of time doing. GLOBE students differed from non-GLOBE students, however, in their likelihood of asserting that scientists spend extensive time on scientific activities that are more social in nature. Higher proportions of GLOBE students believe that scientists spend a great deal of time explaining the results of their experiments, discussing results with other scientists, and defending their points of view. These kinds of activities have been shown to be important aspects of the interactions in scientific laboratories and are associated with scientific insight and discovery (Dunbar, 1996).

In addition, GLOBE students across all three grade levels were more likely than non-GLOBE students to acknowledge that scientists spend a lot of time studying problems without a clear solution, using evidence to support their theory, and using scientific evidence to prove that a theory is true or false. GLOBE students appear to be acquiring a more realistic appreciation of the multifaceted nature of scientific practice. This kind of knowledge does not emerge through textbook learning; rather, it is acquired through the experience of scientific practice and communication with others about that practice.

**Table 6.10**
**Students' Conception of Scientists' Activities: What They Believe Scientists Spend "A Lot" of Time Doing, by GLOBE Participation Status (Percent)**

| Activity | *4th Grade* | | *7th Grade* | | *10th Grade* | |
|---|---|---|---|---|---|---|
| | *GLOBE* | *Non-GLOBE* | *GLOBE* | *Non-GLOBE* | *GLOBE* | *Non-GLOBE* |
| Using evidence to support their theory | 49 | 46 | 67* | 56 | 69 | 76 |
| Explaining the results of an experiment | 62* | 49 | 57 | 52 | 67* | 58 |
| Discussing their results with other scientists | 53* | 43 | 41 | 40 | 62** | 41 |
| Finding evidence showing how things happen in the world | 62 | 59 | 50^ | 44 | 56 | 50 |
| Collecting data | 75** | 53 | 75** | 61 | 75** | 66 |
| Planning experiments and writing reports | 54 | 58 | 39 | 47 | 52 | 49 |
| Studying a problem without a clear solution | 40** | 24 | 35* | 27 | 53* | 39 |
| Using scientific evidence to prove that a theory is true or false | 59^ | 49 | 56 | 59 | 69* | 54 |
| Defending their points of view or ideas | 47** | 33 | 55 | 47 | 71** | 53 |

* $p < .05$ for chi-square on choices between "A lot," "Some," "A little," and "None."
** $p < .01$ for chi-square on choices between "A lot," "Some," "A little," and "None."
^ Marginally significant $p \leq .10$ for chi-square on choices between "A lot," "Some," "A little," and "None."

## Student Attitudes toward Science

Attitudes, goals, and interests give students reasons for engaging in, or withdrawing from, academic tasks. Students' perceptions of the relevance of science content, and its relationship to their own goals and self-worth appear to have significant effects on whether they will be motivated to learn the content itself. "If a student sees himself or herself as becoming a scientist..... then science content and tasks may be perceived as being more important..." (Pintrich, Marx, & Boyle, 1993, p. 183).

GLOBE teachers have very positive perceptions about GLOBE's influence on their students' attitudes toward science. Nearly 60% of GLOBE teachers said that GLOBE had improved their students' view of themselves as capable of doing science "very much," and 53% of teachers reported that GLOBE had increased their students' interest in taking science courses "very much." Corresponding percentages for exploring science questions outside the classroom and talking about what they have learned in science were 45% and 34%, respectively. One of our case study teachers described how GLOBE has affected his students' motivation level. Todd Toth reported that many of his high school students who had never before been able to sustain any interest in science had become motivated to finish their projects and showed excitement about collecting science data after the introduction of GLOBE. Students who would never have used a computer had a chance to do so because of the GLOBE program. Many of the students were very excited about using both the computer technology and the GPS equipment, which they viewed as relevant to their own lives because of applications to recreational activities such as hunting and fishing.

When the GLOBE students themselves are queried about their attitudes, they express positive ideas about science. As shown in Table 6.11, 87% agreed with the statement that what we learn from science can make the world a better place, and 59% said that after doing GLOBE they were more interested in taking science classes. Such positive attitudes do not appear to be the exclusive result of participation in GLOBE, however,

**Table 6.11**
**Percent Agreement with Science Attitude Statements**

| | *GLOBE* | | | *Non-GLOBE* | | |
|---|---|---|---|---|---|---|
| ***Statement*** | ***4th*** | ***7th/ 10th*** | ***Total*** | ***4th*** | ***7th/ 10th*** | ***Total*** |
| What we learn from science can make the world a better place | 95 | 80* | 87 | 94 | 85 | 88 |
| You need math to do science | 83* | 86** | 83 | 75 | 83 | 83 |
| I want to be a scientist | 38* | 30** | 34** | 49 | 18 | 25 |
| What happens in one place can change things in other places | 85** | 76** | 77** | 63 | 76 | 73 |
| I'm more interested in science/ I like to study science | 80 | 39** | 59 | 82 | 48 | 58 |

* $p < .05$ for chi-square on choices "Neither agree nor disagree," "Disagree," or "Strongly disagree."
** $p < .01$ for chi-square on choices "Neither agree nor disagree," "Disagree," or "Strongly disagree."

because non-GLOBE students in our comparison group gave similarly positive responses: 88% agreed with the statement that what we learn from science can help make the world a better place, and 58% reported that they like to study science. Despite these similar attitudes, GLOBE students were significantly more likely to aspire to a career in science; about one in three GLOBE students (34%) reported that they might want a career in science, compared with only one in four non-GLOBE students (25%), $p < .05$.

Both groups of students were well aware of the need to use math in order to do science, with 83% of both student groups agreeing with this statement. Summing the data across grade levels, however, masks a possible influence of GLOBE on the age at which students realize the importance of math in doing science. At the 7th- and 10th-grade levels, 86% of GLOBE students and 83% of non-GLOBE students indicated that math was needed for science. However, whereas about the same percentage of GLOBE 4th-graders as secondary students (83%) also stated that math was important for science, significantly fewer non-GLOBE 4th-graders appreciated the relevance of math (75%, $p < .05$).

# Chapter 7. Conclusion: Toward Refining the GLOBE Program

In this final chapter, we seek to provide some perspective on our data, summarizing both program strengths and areas where refinements could improve its educational effectiveness.

## Program Strengths

In the Year 1 evaluation report, we noted four highly attractive features of the program's design:

- Extremely high student and teacher enthusiasm
- Flexibility, making it adaptable to a broad range of settings and students
- Model for instructional use of Internet connection and resources
- Stimulus for collaborative learning and cross-age activities.

These qualities remain attractive parts of GLOBE as the program has grown and evolved. What's more, after a second year of implementation, we can now point to empirical evidence that GLOBE is in fact influencing science teaching and learning in ways that are commensurate with the movement toward higher standards and inquiry-based approaches in science instruction.

Compared with teachers who want to implement GLOBE but have not yet taken the training or started the program, GLOBE teachers spend less science instruction time teaching vocabulary or having students complete worksheets. They spend more time having students do science: taking measurements or observations, applying science concepts, and analyzing and interpreting data. Moreover, students exposed to GLOBE perform better than their age-mates in comparison classes on assessments not only of their ability to take the kinds of measurements used in GLOBE but also of their ability to select options congruent with sound sampling and measurement principles and to interpret data and apply science concepts. For those Earth science concepts in which they received some instruction, GLOBE students outperformed non-GLOBE students by 53% versus 36% for knowledge of measurement procedures, 56% versus 51% for sampling and measurement principles, and 48% versus 42% for ability to interpret data and apply concepts. GLOBE students also have a fuller appreciation of what it means to be a scientist and are more interested in science careers (34% v. 25%).

The fact that these differences have emerged after only 2 years in a program that allows as much latitude as GLOBE does in terms of how it is implemented is a testament to the strength of the basic elements of the program design.

These findings relate most strongly to the GLOBE objective of enhancing science and mathematics achievement.  Our evidence with regard to GLOBE's other two objectives (to increase environmental awareness and to add to the knowledge base concerning Earth systems) is thinner at this time.  Environmental awareness is a difficult concept to measure.  Several of our survey items designed to tap this concept elicited highly positive statements from GLOBE students, but were equally likely to be endorsed by students of teachers who had signed up for GLOBE training but not yet implemented the program. Eighty-seven percent of GLOBE students and 88% of non-GLOBE students, for example, agreed with the statement "What we learn from science can make the world a better place."  Seventy-six percent of both GLOBE and non-GLOBE middle and secondary students in our survey sample agreed with the statement that "What happens in one place can change things in other places."  We did see a difference between GLOBE and non-GLOBE 4th-graders' responses to this item:  85% of GLOBE 4th-graders agreed, compared with 63% of non-GLOBE 4th-graders.  Anecdotal evidence of increased environmental awareness on the part of GLOBE students is provided by teachers at case study sites and in responses to open-ended survey items.

In light of the fact that the GLOBE II data collection protocols were just starting to be implemented during school year 1996-97, we judged it too early to assess GLOBE's contribution to the scientific database.  In the third year of the evaluation, the GLOBE II scientists will be surveyed concerning the usability of the student data collected for their investigation areas, the results of quality checks they have done on the data, and the analyses and publications they have produced using GLOBE data.

## Emerging Issues

As stated above, the GLOBE program can point to evidence of progress toward meeting its objective of supporting mathematics and science learning.  While keeping this positive "big picture" in mind, we also need to examine areas in which program implementation processes could be improved.  (Areas for improvement identified in the Year 1 report and steps taken to address them are summarized in Chapter 1.)  On the basis of the Year 2 data and analyses, we identified seven issues for discussion:

- Increasing the proportion of GLOBE-trained teachers who fully implement the program.
- Supporting implementation at a variety of grade levels and in varying contexts.
- Better preparing and incentivizing teachers to try out new protocols and learning activities.
- Supporting teachers in training their colleagues to implement GLOBE.
- Sustaining school interest and involvement over time.
- Increasing support for classroom assessments.
- Monitoring program quality as more training is provided by "third parties."

**Increasing the proportion of GLOBE-trained teachers who fully implement the program.** GLOBE training is provided by a team of five scientists and educators over a three and a half day period to groups averaging around 30 teachers. It is an intensive experience, and teachers give it high marks in terms of quality. Even so, many of the teachers who complete the training never get a full-fledged program started with their students. In the spring 1996 survey of a representative sample of teachers trained by GLOBE in 1995, 30% said that they had not yet implemented the program with students more than a year after receiving their training. Of the 70% who said they had implemented the program, nearly a quarter said that they had not reported any data. In a similar vein, analyses conducted for this report showed that of the first 2,000 schools to have teachers trained by GLOBE (all trained by summer 1996), 40% had never reported any data as of June 1997. Although students may be benefiting from GLOBE content in schools that are not reporting data, such implementations fall short of the original GLOBE concept and do not contribute toward the GLOBE goal of increasing scientific knowledge about Earth systems.

One approach to this issue would be the provision of options for different kinds of participation in GLOBE. This strategy would provide teachers with an officially recognized and supported option for doing a thorough job with a core, more easily implemented but still meaningful subset of the entire GLOBE program. More extensive training and support resources (both on GLOBE's part and on the part of teachers and schools) could be expended more selectively on those sites that are motivated and equipped to follow through.

The SPARCE program provides an example of one such strategy: schools that believe they would like to join the program are sent instructions for conducting the simplest of the measurements. After a school has started submitting data for the simplest protocols, it qualifies to receive in-person training on additional data collection protocols and full-fledged membership in the program.

GLOBE is likely to prefer a more elaborated initial level of involvement. A proposal currently under consideration by GLOBE is the design of a shorter GLOBE "basic" training, which all teachers would take, and of an "advanced" training option for those teachers who are ready to move beyond the more basic protocols and learning activities.

Another approach would be requiring schools to demonstrate a stronger commitment to the community of learners model: schools could be required to submit a plan for implementing GLOBE in multiple classrooms, commit to training and equipping more than one teacher, and/or commit to taking on protocols from more than one investigation area before being accepted for training. Some educational programs require administrators to participate in part of the training; others require a certain proportion of a school's staff to indicate a commitment to support the program.

**Supporting implementation at a variety of grade levels and in varying contexts.** Both primary grade teachers and teachers at the upper grades express some concerns about the match between GLOBE and their students' level or their required curriculum. We have enough existence proofs (for example, in our case study schools) to demonstrate that GLOBE *can* be effectively implemented in these contexts, but often teachers need to adapt GLOBE and develop additional resources to make it work for their students. We would suggest further expanding the Resource Room on the GLOBE Web site and the teacher listservs to encompass "special interest groups," such as primary grade GLOBE teachers, science and chemistry GLOBE teachers, social studies GLOBE teachers, and so on. A modest grant program to support teachers for compiling resources and sharing them with other teachers through the Web site and/or for moderating electronic discussion groups could have large payoffs.

**Providing in-depth preparation, supports, and incentives for teachers to implement a range of protocols and learning activities**. As the GLOBE program continues to mature, it is appropriate to turn more attention to obtaining better data sets with increased scientific as well as educational value. The timing of the release of the second-edition Teacher's Guide (in November 1996) was no doubt one factor in the low implementation rate for new protocols. But it seems likely also that teachers are in danger of getting overwhelmed by new GLOBE materials and will continue to stick with the “tried and true.”

One strategy the program is using to encourage implementation of new protocols is increasing the amount and immediacy of interactions with GLOBE scientists. Scientists’ interactions with schools in the course of developing and field testing protocols and learning activities, scientists’ involvement in GLOBE training sessions, and teachers’ participation in GLOBE conferences, Web chats, and other electronic communications have all increased the amount of teacher-scientist interaction.

The El Niño investigation planned for 1997-98 is another strategy. The investigation provides a motivating context with a clear rationale for the need for consistency in data collection and a greater sense of interaction with the scientific community as research questions and data patterns unfold.

Another strategy would involve identifying and highlighting a smaller key subset of basic or “core” GLOBE protocols. These protocols would involve multiple investigation areas and be central to an Earth systems understanding. Giving teachers a sense of what is most important (and thus a smaller set of protocols as a target) should raise the likelihood of achieving more balanced data collections across the various investigations. GLOBE Star status could be awarded on the basis of achieving an adequate data set in all of the areas identified as core, rather than on the sheer number of pieces of data reported (regardless of type).

**Supporting teachers in training their colleagues to implement GLOBE.** To the extent that schools are moving toward distributed implementation by multiple teachers, previously trained GLOBE teachers become trainers themselves. Some of these teachers are involved in the GLOBE-run training, through which they in essence receive refresher training and updates on GLOBE developments in addition to providing training to new teachers. GLOBE teachers not involved in the teacher training program, however, have fewer supports for “refreshing” their knowledge of GLOBE protocols and learning activities. Many GLOBE teacher trainers have asserted that there are aspects of the current GLOBE program that they do not believe they would be able to implement if they had not been involved in multiple training sessions.

This situation suggests several possible lines of attack. One is to provide GLOBE teachers with more supports for training their colleagues. The GLOBE program is moving in this direction by making the trainers’ slides available on the World Wide Web and letting a contract for the development of GLOBE training videotapes. The program is also considering developing some Web-based training activities. These materials will give GLOBE teachers much better support for their work in training others.

A second, complementary strategy is to involve a larger proportion of GLOBE teachers in training others. Some educational programs offer additional training to become "mentor teachers." Mentor teachers then are expected to support other teachers in their area, either by visiting schools or through phone or e-mail contact. University credit, honoraria, or supported opportunities to attend GLOBE conferences could serve as incentives for taking on the mentor teacher role.

**Sustaining school interest and involvement over time.** Of the 910 U.S. schools that reported GLOBE data in 1995-96, 32% did not report data in 1996-97. Although this attrition rate is not at all bad as education programs go, it is higher than the GLOBE program would like. Such data reflect the fact that educational innovations are susceptible to teacher turnover, competing demands, and changes in schedules. Moreover, if the school's GLOBE program is dependent upon the efforts of a single teacher, it will be particularly vulnerable. To the extent that there is greater commitment to the program on the part of the school and that the commitment extends beyond a single GLOBE teacher, greater program continuity can be expected.

The GLOBE program is taking steps to encourage a multi-teacher community of learners implementation approach and to provide more interest-sustaining "events" such as Web chats, a teacher conference (held in Boulder in July 1997), an international student and teacher conference (to be held in Helsinki in June 1998), and special projects such as the El Niño investigation.

**Increasing support for classroom assessments.** As noted earlier in this report, the revised Teacher's Guide contains sections on assessment for each investigation area, but these sections are often only loosely specified and are nearly always incomplete in that they lack specifications for evaluating students' work. GLOBE is in the process of letting a grant to support the development of a much more fully worked-out set of assessment materials for classroom use. Another way in which GLOBE could move toward supporting better assessment is in adapting software tools for student use in keeping electronic GLOBE journals. Such journals have been used in earlier projects, such as Collaborative Visualizations of Scientific Data (CoVis), to encourage students to make their understanding of the data they are working with explicit. The software interface is structured in a way that prompts students to clarify their ideas and reflect on what they have learned from their investigations. By reviewing students' electronic journals, teachers can get a "window" into their thinking and are in a better position to identify and correct misconceptions. In addition to increasing the amount of reflection students engage in, this tool would also increase the amount of writing students do in connection with their GLOBE work.

**Monitoring program quality as more training is provided by "third parties."** As more teachers learn how to implement GLOBE, either from colleagues at their school or from GLOBE "franchises," questions about quality control are natural. Although there is scrutiny of the qualifications and training of the trainers, train-the-trainer models are susceptible to dilution of expertise. The tools for supporting GLOBE trainers discussed above are one way to address this issue. Another possibility, without being heavy handed about certification or monitoring, is to provide newly trained GLOBE teachers with the opportunities to complete self-assessments in the various investigation areas. These could be made available on the Web for private use, along with feedback on the teacher's performance and referral to resources for strengthening knowledge in areas that are weak.

In addition to providing these tools for teachers, the program is getting to a stage where it makes sense to develop indices of program quality (such as number of students and teachers involved, amount of analytic work and original investigations, adequacy of data set contributed) and to start examining the relationship between the type of training teachers have received and the quality of the GLOBE program they implement. Such analyses may show variants of the conventional GLOBE training model that are significantly less or significantly more effective. In either case, implications can be drawn which will inform further refinement of the GLOBE program.

## Final Thought

The GLOBE program evolved considerably between its first and second year with:

- New, greatly expanded Teacher's Guide.
- Much better balance between educational content and data interpretation and analysis on the one hand and the collection of data on the other.
- Emphasis on training more than one teacher within a GLOBE school.
- Wider range of technology tools to support analytic and reflective activities as well as communication.
- Greater interaction between GLOBE scientists and GLOBE teachers.

Although the pace of change has left nearly all program participants with the sense that they are constantly straining to “catch up” with the latest developments, few doubt that the effort has been worth it. GLOBE’s attempt to combine science, education, and technology on an unprecedented international scale has gone beyond the vision stage, to become a fact of life in hundreds of classrooms around the world.

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# APPENDIX:

# Teacher and Student Surveys

**OMB No. 06480310**
**Approval Expires: November 30, 1999**

# A SURVEY OF TEACHERS PARTICIPATING IN THE GLOBE PROGRAM

The public reporting burden for this collection of information is estimated to average 20 minutes, including the time for reviewing instructions, searching data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to The GLOBE Program, 744 Jackson Place, Washington, D.C. 20503.

The information provided by respondents in this survey will be used to prepare summaries in aggregate form that do not identify individual respondents. The anonymity of respondents will be assured to the extent provided by law, including the Freedom of Information Act. Reasonable steps will be taken in the processing and analysis of respondent data to attempt to avoid any unintentional dissemination of information in which respondents and/or their responses may be identified.

Notwithstanding any other provision of law, no person is required to respond to nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirement of the Paperwork Reduction Act unless that collection of information displays a currently valid OMB control number.

# GLOBE Teacher Survey

Name: ________________________________

Today's Date__________ (month/day/year)

## GLOBE IMPLEMENTATION AT YOUR SCHOOL

1. **How many teachers at your school are implementing GLOBE activities with students?**

   Number of teachers: ____

2. **During which periods have you and your school implemented GLOBE activities with students?**
   ***(Circle all numbers that apply in each column.)***

| | | | School Implemented | You Implemented |
|---|---|---|---|---|
| Spring | (Mar-May) | 1995 | 1 | 1 |
| Summer | (Jun-Aug) | 1995 | 2 | 2 |
| Fall | (Sep-Nov) | 1995 | 3 | 3 |
| Winter | (Dec-Feb) | 1995-96 | 4 | 4 |
| Spring | (Mar-May) | 1996 | 5 | 5 |
| Summer | (Jun-Aug) | 1996 | 6 | 6 |
| Fall | (Sep-Nov) | 1996 | 7 | 7 |

3. **How many students at each grade level participate in GLOBE at your school?**
   ***(Enter 0 where appropriate.)***

| Grade level: | K-3 (ages 5-8) | 4-5 (ages 9-10) | 6-8 (ages 11-13) | 9-12 (ages 14 and older) |
|---|---|---|---|---|
| Number of students: | _____ | _____ | _____ | _____ |

4. **Have you made presentations or spoken with groups outside your school about GLOBE?**
   ***(Circle one number.)***

   1 Yes

   0 No

## GLOBE CLASSROOM ACTIVITIES

5. **Think about the *single class* or other setting in which *you* do the most GLOBE-related work with students. With how many students do you work directly in carrying out the GLOBE program?**

   Total number of students in this single class or setting: ________. Of these students, indicate the number in each grade level:

| Grade Level | Number of Students | Grade Level | Number of Students |
|---|---|---|---|
| K | _________ | 7 | _________ |
| 1 | _________ | 8 | _________ |
| 2 | _________ | 9 | _________ |
| 3 | _________ | 10 | _________ |
| 4 | _________ | 11 | _________ |
| 5 | _________ | 12 | _________ |
| 6 | _________ | | |

6. **How would you characterize the *one* class or other setting in which *you* do the most GLOBE-related work with students?** ***(Circle one number in the appropriate column.)***

| **Elementary** | **Middle/Secondary** |
|---|---|
| 1 Comprehensive elementary class | 4 Pull-out program (students taken out of regular class for this activity) |
| 2 Elementary science taught by science resource teacher | 5 Lunch, club, or after-school interest group |
| | 6 Regular middle or secondary class |
| 3 Other elementary: ______________________ | Class title: ________________________________ |

7. **How do you organize your students for GLOBE activities?** ***(Circle one number for each activity.)***

| | | We Don't Do This Activity | Single Student or Small Group Does It | Multiple Small Groups Do It in Parallel | Whole Class Does It Together |
|---|---|---|---|---|---|
| a. | Take GLOBE measurements. | 1 | 2 | 3 | 4 |
| b. | Enter GLOBE data on the computer. | 1 | 2 | 3 | 4 |
| c. | Explore information on GLOBE Web site. | 1 | 2 | 3 | 4 |
| d. | Analyze, discuss, or interpret GLOBE data. | 1 | 2 | 3 | 4 |
| e. | Telecommunicate with other GLOBE schools. | 1 | 2 | 3 | 4 |
| f. | Engage in GLOBE learning activities. | 1 | 2 | 3 | 4 |

8. **Explain how the GLOBE investigations fit into your existing curriculum.**

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

____________________________________________________________

9. **Think about the computers you use for GLOBE. Where are these computers located, and how many of each type do you use in each location?** ***(Enter a number for each applicable category.)***

| | Location | # PC Compatible | # Macintosh Compatible | # Apple II Compatible | # Other *(please specify)* __________ |
|---|---|---|---|---|---|
| 1. | Your regular classroom | ____ | ____ | ____ | ____ |
| 2. | Computer laboratory | ____ | ____ | ____ | ____ |
| 3. | Library or media center | ____ | ____ | ____ | ____ |
| 4. | Other *(please specify)*: ____________ | ____ | ____ | ____ | ____ |

10. **How often have you or your students used these features of the GLOBE Web site?** ***(Circle one number for each feature.)***

| | | Not at All | Once | More Than Once But Less Than Once a Week | Average of Once a Week or More |
|---|---|---|---|---|---|
| a. | Visualizations of student data | 1 | 2 | 3 | 4 |
| b. | Visualizations of reference data | 1 | 2 | 3 | 4 |
| c. | Visualization Gallery | 1 | 2 | 3 | 4 |
| d. | GLOBEMail | 1 | 2 | 3 | 4 |
| e. | GLOBE Stars | 1 | 2 | 3 | 4 |
| f. | GLOBE Student Data Archive | 1 | 2 | 3 | 4 |
| g. | GLOBE Bulletin | 1 | 2 | 3 | 4 |
| h. | Scientist Corner | 1 | 2 | 3 | 4 |
| i. | Frequently Asked Questions | 1 | 2 | 3 | 4 |
| j. | WebChat | 1 | 2 | 3 | 4 |
| k. | School interaction (maps, school information, etc.) | 1 | 2 | 3 | 4 |

**11. Which GLOBE protocols do you plan to implement with your students?**
*(Circle one number on the scale for each protocol.)*

| Scale: | Definitely will NOT Implement | Might Implement | Definitely Plan to Implement | Have Already Implemented |
|---|---|---|---|---|
| | *1* | *2* | *3* | *4* |

| **A. Atmosphere Protocols** | | | | |
|---|---|---|---|---|
| a. Cloud Type | 1 | 2 | 3 | 4 |
| b. Cloud Cover | 1 | 2 | 3 | 4 |
| c. Rainfall | 1 | 2 | 3 | 4 |
| d. Solid Precipitation | 1 | 2 | 3 | 4 |
| e. Max/Min and Current Temperature | 1 | 2 | 3 | 4 |

| **B. Hydrology Protocols** | | | | |
|---|---|---|---|---|
| a. Water Temperature | 1 | 2 | 3 | 4 |
| b. pH | 1 | 2 | 3 | 4 |
| c. Dissolved Oxygen | 1 | 2 | 3 | 4 |
| d. Alkalinity | 1 | 2 | 3 | 4 |
| e. Electrical Conductivity | 1 | 2 | 3 | 4 |

| **C. Land Cover/Biology Protocols** | | | | |
|---|---|---|---|---|
| a. Establishing Study Sites | 1 | 2 | 3 | 4 |
| b. Land Cover Map (MUC Classification) | 1 | 2 | 3 | 4 |
| c. Species Identification | 1 | 2 | 3 | 4 |
| d. Biometry | 1 | 2 | 3 | 4 |
| e. Qualitative Validation Data Collection | 1 | 2 | 3 | 4 |
| f. Quantitative Validation Data Collection | 1 | 2 | 3 | 4 |
| g. Accuracy Assessment | 1 | 2 | 3 | 4 |

| **D. Soil Protocols** | | | | |
|---|---|---|---|---|
| a. Soil Characterization | 1 | 2 | 3 | 4 |
| b. Soil Moisture | 1 | 2 | 3 | 4 |

| **E. GPS Protocol** | | | | |
|---|---|---|---|---|
| a. GPS Measurement | 1 | 2 | 3 | 4 |

**12. Which GLOBE learning activities do you plan to implement with your students?**
*(Circle one number on the scale for each learning activity.)*

| Scale: | Definitely will NOT Implement | Might Implement | Definitely Plan to Implement | Have Already Implemented |
|---|---|---|---|---|
| | *1* | *2* | *3* | *4* |

| **A. Atmosphere Learning Activities** | | | | |
|---|---|---|---|---|
| a. Observing, Describing, and Identifying Clouds | 1 | 2 | 3 | 4 |
| b. Estimating Cloud Cover: A Simulation | 1 | 2 | 3 | 4 |
| c. Studying the Instrument Shelter | 1 | 2 | 3 | 4 |
| d. Precipitation: Location Bias in Measurement | 1 | 2 | 3 | 4 |
| e. Building a Thermometer | 1 | 2 | 3 | 4 |
| f. Land, Water, and Air | 1 | 2 | 3 | 4 |
| g. Cloud Watch | 1 | 2 | 3 | 4 |

| **B. Hydrology Learning Activities** | | | | |
|---|---|---|---|---|
| a. Water Walk | 1 | 2 | 3 | 4 |
| b. Model Your Watershed | 1 | 2 | 3 | 4 |
| c. Practicing the Protocols | 1 | 2 | 3 | 4 |
| d. The pH Game | 1 | 2 | 3 | 4 |
| e. What Can Live Here? | 1 | 2 | 3 | 4 |
| f. Further Investigations | 1 | 2 | 3 | 4 |

12. **(Continued) Which GLOBE learning activities do you plan to implement with your students?** ***(Circle one number on the scale for each learning activity.)***

| Scale: | Definitely will NOT Implement | Might Implement | Definitely Plan to Implement | Have Already Implemented |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |

| C. Land Cover/Biometry Learning Activities | | | | |
|---|---|---|---|---|
| a. Odyssey of the Eyes | 1 | 2 | 3 | 4 |
| b. Some Like It Hot | 1 | 2 | 3 | 4 |
| c. Discovery Area | 1 | 2 | 3 | 4 |
| d. Site Seeing | 1 | 2 | 3 | 4 |
| e. Seasonal Changes in Your Biometry Site | 1 | 2 | 3 | 4 |
| f. Bird Classification | 1 | 2 | 3 | 4 |
| g. What's the Difference? | 1 | 2 | 3 | 4 |

| D. Soil Learning Activities | | | | |
|---|---|---|---|---|
| a. Soil and My Backyard | 1 | 2 | 3 | 4 |
| b. A Field View of Soil—Digging Around | 1 | 2 | 3 | 4 |
| c. The Data Game | 1 | 2 | 3 | 4 |
| d. How Much Water Does Soil Hold? | 1 | 2 | 3 | 4 |
| e. Soil: The Great Decomposer | 1 | 2 | 3 | 4 |

| E. GPS Learning Activities | | | | |
|---|---|---|---|---|
| a. Relative and Absolute Directions | 1 | 2 | 3 | 4 |
| b. Working with Angles | 1 | 2 | 3 | 4 |
| c. Offset GPS Measurements | 1 | 2 | 3 | 4 |
| d. What Is the Right Answer? | 1 | 2 | 3 | 4 |

| F. Seasons Learning Activities | | | | |
|---|---|---|---|---|
| a. Observing Seasonal Changes in the Local Study Sites | 1 | 2 | 3 | 4 |
| b. Students Ask Questions About the Seasons | 1 | 2 | 3 | 4 |
| c. What Should Your Students Investigate? | 1 | 2 | 3 | 4 |
| d. Using Graphs to Explore Annual Temperature Cycles | 1 | 2 | 3 | 4 |
| e. Select Another GLOBE School for Detailed Study | 1 | 2 | 3 | 4 |
| f. Preparing a Report on the Investigations | 1 | 2 | 3 | 4 |

13. **Have you designed any additional investigations or data analysis activities that build upon the basic GLOBE program?**

1 Yes *(If yes, please describe any such activities that you have found to be particularly successful with your students.)*

________________________________________

________________________________________

________________________________________

0 No

## GLOBE'S IMPACT ON STUDENTS

**14. How much have GLOBE activities helped your students to improve their skills in the following areas?** ***(Circle one number for each skill area.)***

| | | Not at All | Not Very Much | Some-what | Very Much | Don't Know |
|---|---|---|---|---|---|---|
| a. | Measurement skills | 1 | 2 | 3 | 4 | 9 |
| b. | Observational skills | 1 | 2 | 3 | 4 | 9 |
| c. | Map skills | 1 | 2 | 3 | 4 | 9 |
| d. | Technology skills | 1 | 2 | 3 | 4 | 9 |
| e. | Ability to work in small groups | 1 | 2 | 3 | 4 | 9 |
| f. | Ability to understand, represent, and interpret data | 1 | 2 | 3 | 4 | 9 |
| g. | Critical-thinking skills | 1 | 2 | 3 | 4 | 9 |
| h. | English language skills | 1 | 2 | 3 | 4 | 9 |
| i. | Ability to regulate their own learning | 1 | 2 | 3 | 4 | 9 |

**15. How much have GLOBE activities increased your students' knowledge in the following areas?** ***(Circle one number for each area.)***

| | | Not at All | Not Very Much | Some-what | Very Much | Does not apply |
|---|---|---|---|---|---|---|
| a. | Hydrology (e.g., properties of water) | 1 | 2 | 3 | 4 | 9 |
| b. | Atmosphere and climate | 1 | 2 | 3 | 4 | 9 |
| c. | Land cover/Biology (e.g., biometry) | 1 | 2 | 3 | 4 | 9 |
| d. | Soil | 1 | 2 | 3 | 4 | 9 |
| e. | Global Positioning System | 1 | 2 | 3 | 4 | 9 |
| f. | Seasons | 1 | 2 | 3 | 4 | 9 |
| g. | Geography | 1 | 2 | 3 | 4 | 9 |
| h. | Internet science resources | 1 | 2 | 3 | 4 | 9 |

**16. How much have your students' attitudes toward science improved after taking part in GLOBE?** ***(Circle one number in each row.)***

| | | Not at All | Not Very Much | Some-what | Very Much | Don't Know |
|---|---|---|---|---|---|---|
| a. | View of themselves as capable of doing science. | 1 | 2 | 3 | 4 | 9 |
| b. | Interest in taking science classes. | 1 | 2 | 3 | 4 | 9 |
| c. | Interest in exploring scientific questions outside the classroom. | 1 | 2 | 3 | 4 | 9 |
| d. | Time spent describing what they have learned through GLOBE to friends or family. | 1 | 2 | 3 | 4 | 9 |

## CHALLENGES IN IMPLEMENTING GLOBE

**17. How great a challenge has each of the following pedagogical issues been for you as you implemented the GLOBE program** ***during the 1996-97 school year?***
***(Circle one number for each issue.)***

| | | This Has Been Easy | This has Been Somewhat Challenging | This has Been a Major Challenge | Don't Know/ Have Not Yet Tackled This Issue |
|---|---|---|---|---|---|
| a. | Integrating GLOBE with the rest of the curriculum. | 1 | 2 | 3 | 9 |
| b. | Finding time for GLOBE activities, given other curriculum and testing requirements. | 1 | 2 | 3 | 9 |
| c. | Presenting GLOBE concepts and activities at the right level for your students (e.g., trying to estimate percentage of cloud cover when students haven't learned percentages yet). | 1 | 2 | 3 | 9 |
| d. | Assessing what students are learning from GLOBE. | 1 | 2 | 3 | 9 |
| e. | Maintaining good student behavior during GLOBE activities/instruction. | 1 | 2 | 3 | 9 |
| f. | Finding appropriate activities for the rest of the class while a few students are collecting or submitting GLOBE data. | 1 | 2 | 3 | 9 |

**18. How great a challenge has each of the following logistical and organizational issues been for you as you implemented the GLOBE program** ***during the 1996-97 school year?***
***(Circle one number for each issue.)***

| | | This Has Been Easy | This has Been Somewhat Challenging | This has Been a Major Challenge | Don't Know/ Have Not Yet Tackled This Issue |
|---|---|---|---|---|---|
| a. | Finding time to prepare for implementing GLOBE activities. | 1 | 2 | 3 | 9 |
| b. | Having time to complete GLOBE activities within the school's schedule constraints (e.g., trying to fit GLOBE activities into lunch period). | 1 | 2 | 3 | 9 |
| c. | Getting support from school administration/other teachers. | 1 | 2 | 3 | 9 |
| d. | Finding funds for acquiring scientific measurement instruments. | 1 | 2 | 3 | 9 |
| e. | Getting data collection instruments in time for planned activities. | 1 | 2 | 3 | 9 |
| f. | Collecting data on weekends, vacations, etc. | 1 | 2 | 3 | 9 |
| g. | Keeping GLOBE equipment secure (i.e., vandalism, theft). | 1 | 2 | 3 | 9 |
| h. | Getting the data collection equipment to work properly. | 1 | 2 | 3 | 9 |
| i. | Getting to data collection site (e.g., water site). | 1 | 2 | 3 | 9 |
| j. | Getting access to adequate computers. | 1 | 2 | 3 | 9 |
| k. | Obtaining a phone line. | 1 | 2 | 3 | 9 |
| l. | Obtaining an Internet service provider. | 1 | 2 | 3 | 9 |
| m. | Obtaining a computer with modem. | 1 | 2 | 3 | 9 |
| n | Obtaining technical support for using computers. | 1 | 2 | 3 | 9 |
| o. | Logging on to the GLOBE server. | 1 | 2 | 3 | 9 |
| p. | Other *(please specify)*: ______________________ | 1 | 2 | 3 | 9 |

19. **[OPTIONAL] Do you have a useful strategy to share for overcoming a significant challenge in implementing GLOBE? If so, please describe the challenge and your strategy for dealing with it.**

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

__________________________________________________________

## GLOBE TEACHER SUPPORT

20. **From whom did you receive GLOBE training?** ***(Circle one.)***

1 Training workshop organized by GLOBE staff
2 Training at your school or a nearby location from a local GLOBE teacher
3 University school of education workshop
4 I have not been trained ***(Skip to question 22.)***
5 Other *(specify):* ____________________________________

21. **When did you receive your GLOBE training?** ***(Circle one.)***

1 Before June 1996  2 Summer (June-August) 1996  3 After August 1996

22. **Think about the training and support materials you have received from GLOBE. How well were you prepared to implement each of the following?** ***(Circle one for each item.)***

| *Scale:* | *Definitely NOT Prepared to Implement* | *Partially Prepared to Implement* | *Adequately Prepared to Implement* | *Fully Prepared to Implement with Comfort* |
|---|---|---|---|---|
| | *1* | *2* | *3* | *4* |

| | **A. Atmosphere Investigation** | | | | | | **D. Soil Investigation** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| a. | Atmosphere Protocols | 1 | 2 | 3 | 4 | a. | Soil Protocols | 1 | 2 | 3 | 4 |
| b. | Atmosphere Educational Activities | 1 | 2 | 3 | 4 | b. | Soil Educational Activities | 1 | 2 | 3 | 4 |
| | **B. Hydrology Investigation** | | | | | | **E. GPS Investigation** | | | | |
| a. | Hydrology Protocols | 1 | 2 | 3 | 4 | a. | GPS Protocol | 1 | 2 | 3 | 4 |
| b. | Hydrology Educational Activities | 1 | 2 | 3 | 4 | b. | GPS Educational Activities | 1 | 2 | 3 | 4 |
| | **C. Land Cover/Biology Investigation** | | | | | | **F. Seasons Investigation** | | | | |
| a. | Land Cover/Biology Protocols | 1 | 2 | 3 | 4 | a. | Seasons Educational Activities | 1 | 2 | 3 | 4 |
| b. | Land Cover/Biology Educational Activities | 1 | 2 | 3 | 4 | | | | | | |

22. (Continued) **Think about the training and support materials you have received from GLOBE. How well were you prepared to implement each of the following?** *(Circle one for each activity.)*

| *Scale:* | *Definitely NOT Prepared to Implement* | *Partially Prepared to Implement* | *Adequately Prepared to Implement* | *Fully Prepared to Implement with Comfort* |
|---|---|---|---|---|
| | *1* | *2* | *3* | *4* |

| **G. Web Activities** | | | | |
|---|---|---|---|---|
| a. Use of GLOBEMail | 1 | 2 | 3 | 4 |
| b. Use of GLOBE Student Data Archive | 1 | 2 | 3 | 4 |
| c. Use of visualization data | 1 | 2 | 3 | 4 |

**23. How often have you used the following GLOBE teacher services or materials?** ***(Circle one in each row.)***

| | Not at All | Once | More Than Once But Less Than Once a Week | Average of Once a Week or More |
|---|---|---|---|---|
| a. Teacher's Guide, First edition | 1 | 2 | 3 | 4 |
| b. Teacher's Guide, Fall 1996 edition | 1 | 2 | 3 | 4 |
| c. GLOBE Help Desk | 1 | 2 | 3 | 4 |
| d. GLOBE Resource Room | 1 | 2 | 3 | 4 |

**24. Would you like the GLOBE office to contact you to discuss your support needs?**

1 Yes *(If yes, please circle the number(s) in the box below for the area(s) in which you would like assistance and provide your phone number, best time to contact, and your e-mail address.)*

1 Internet or software issues
2 Science protocols or equipment
3 Education issues
4 Public outreach

*Phone number:* ________ ______________
*Best time to contact:* ______________________________
*E-mail address:* ______________________________

0 No

## SCHOOL INFORMATION

**25. Are schools within your district working together to implement GLOBE?**

1 Yes *(If yes, please describe):* ____________________________________________
____________________________________________

0 No

**26. How would you describe your school?** ***(Circle one in each column.)***

| | | |
|---|---|---|
| 1 Public | 1 Rural | 1 Regular |
| 2 Private | 2 Suburban | 2 Alternative (e.g., serving a special population) |
| | 3 Urban | |

Thank you very much for your help in completing this survey.

If you have any further comments, you may use the space below.

**OMB No. 06480310**
**Approval Expires: November 30, 1999**

# DIRECTIONS FOR ADMINISTERING THE GLOBE STUDENT SURVEY

The public reporting burden for this collection of information is estimated to be 30 minutes for students completing the assessment. The time required for teachers is estimated at 10 minutes, including the time for reviewing instructions, searching data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to The GLOBE Program, 744 Jackson Place, Washington, D.C. 20503.

The information provided by respondents in this survey will be used to prepare summaries in aggregate form that do not identify individual respondents. The anonymity of respondents will be assured to the extent provided by law, including the Freedom of Information Act. Reasonable steps will be taken in the processing and analysis of respondent data to attempt to avoid any unintentional dissemination of information in which respondents and/or their responses may be identified.

Notwithstanding any other provision of law, no person is required to respond to nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirement of the Paperwork Reduction Act unless that collection of information displays a currently valid OMB control number.

April 9, 1997

Dear GLOBE Teacher:

Your GLOBE students have been selected to participate in a national evaluation of the GLOBE program. The evaluation is focusing on students in the 4th, 7th, and 10th grades whose school is in its second year of implementing GLOBE. We have enclosed copies of the GLOBE Student Survey for completion by every 4th-, 7th-, or 10th- grader in your **single most active GLOBE class or club**. To insure a representative survey sample, it is important that **all** of the 4th-, 7th-, or 10th- graders in your single most active GLOBE class or club complete the Student Survey.

The purposes of the Student Survey are to :

- Provide information about the frequency with which students are involved in various aspects of GLOBE and the degree of interest these various aspects inspire.
- Ascertain GLOBE students' attitudes toward science and level of understanding of what is involved in conducting scientific investigations.
- Assess what students are learning through participation in GLOBE and GLOBE-related activities.

The assessment portion of the Student Survey (Part II) is designed to tap three different kinds of knowledge and understanding related to GLOBE:

- Knowledge of how to conduct the GLOBE measurement protocols.
- Understanding of data quality and measurement concepts.
- Understanding of earth science concepts and how to apply them to novel problems or data sets.

Some of the material in the student assessment may relate to aspects of GLOBE which you have not implemented with your students. Nevertheless, for research purposes, it is important that your students attempt to answer every question to the best of their ability.

Responses from GLOBE students will be compared to those of students at the same grade level who have not been exposed to GLOBE. After all of your Student Surveys have been submitted and analyzed, we will provide you with feedback concerning how your class performed in the three areas being assessed compared with the national samples of GLOBE and non-GLOBE students.

Classes submitting Student Surveys for 90% or more of their students will receive a $20 money order for use in purchasing refreshments or whatever other reward you deem appropriate.

For us to make sense of the Student Survey responses, we need to know a few things about your class and its involvement with GLOBE and related activities. Please take a few minutes to answer the questions on the enclosed sheet and return your answers with the completed Student Surveys. Please complete this Class Information Sheet even if you are submitting a GLOBE Teacher Survey this spring.

All materials should be mailed in the enclosed post-paid envelope to:

GLOBE Evaluation
SRI International
Room BS123
333 Ravenswood Avenue
Menlo Park, CA 94025-3493

We greatly appreciate your class' contribution to this national evaluation by completing the survey. If you have any questions or need additional copies of the Student Survey, please contact:

Amy Lewis: Tel: (800) 682-9308 E-Mail alewis@unix.sri.com.

## Class Information Sheet

1. In what class (provide class title) or club are you administering the GLOBE Student Survey?

   ___________________________________

2. How many students in the 4th, 7th, or 10th grade are in this class or club?

   4th graders _________
   7th graders _________
   10th graders _________

3. In the matrix below, please circle 0 for those topic areas you have not yet covered with your current class. For those areas you have covered, please circle those numbers that describe what you had students do in the content area. *(Circle all that apply.)*

Activity key:
0 = I have not covered this topic area with my current class
1 = Students have learned vocabulary and concepts
2 = Students have done observations or taken measurements
3 = Students have applied concepts by generating hypotheses or experiments
4 = Students have analyzed and compared data on these topics, making inferences and explaining findings.

| Content Area | Activity | | | | |
|---|---|---|---|---|---|
| **Weather/Meteorology** | | | | | |
| Earth's atmosphere | 0 | 1 | 2 | 3 | 4 |
| Air temperature | 0 | 1 | 2 | 3 | 4 |
| Precipitation/evaporation/condensation | 0 | 1 | 2 | 3 | 4 |
| Cloud types and weather | 0 | 1 | 2 | 3 | 4 |
| **Water** | | | | | |
| Water cycle | 0 | 1 | 2 | 3 | 4 |
| Indicators of water quality | 0 | 1 | 2 | 3 | 4 |
| **Plants** | | | | | |
| Plant growth and function | 0 | 1 | 2 | 3 | 4 |
| Species Identification | 0 | 1 | 2 | 3 | 4 |
| **Soils** | | | | | |
| Generation of soils | 0 | 1 | 2 | 3 | 4 |
| Soil properties (color, texture, water retention | 0 | 1 | 2 | 3 | 4 |
| **Earth Systems** | | | | | |
| Earth shape and movement | 0 | 1 | 2 | 3 | 4 |
| Seasons | 0 | 1 | 2 | 3 | 4 |
| **Geography** | | | | | |
| Maps, latitude, longitude | 0 | 1 | 2 | 3 | 4 |

4. How would you describe your school? *(Circle one number in each category.)*

| (Mark one) | (Mark one) | (Mark one) |
|---|---|---|
| 1 public | 1 rural | 1 regular |
| 2 private | 2 suburban | 2 alternative |
| | 3 urban | 3 specialized (e.g., serving a special population) |

5. About what percentage of students in your school would you estimate qualify for free or reduced-price lunch? *(Circle one number.)*

| | |
|---|---|
| 1 Fewer than 15% | 3 30-49% |
| 2 15-29% | 4 50% or more |

Thank you very much for completing this information sheet. Please enclose it along with your Student Surveys and send them to:

GLOBE Evaluation
SRI International
Room BS123
333 Ravenswood Avenue
Menlo Park, CA 94025-3493

**OMB No. 0648-0310**
**Approval Expires: November 30, 1999**

# A SURVEY OF 4TH GRADE STUDENTS PARTICIPATING IN THE GLOBE PROGRAM

The public reporting burden for this collection of information is estimated to average 30 minutes per response, including the time for reviewing instructions, searching data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to The GLOBE Program, 744 Jackson Place, Washington, D.C. 20503.

The information provided by respondents in this survey will be used to prepare summaries in aggregate form that do not identify individual respondents. The identity of respondents will be assured to the extent provided by law, including the Freedom of Information Act. Reasonable steps will be taken in the processing and analysis of respondent data to attempt to avoid any unintentional dissemination of information in which respondents and/or their responses may be identified.

Notwithstanding any other provision of law, no person is required to respond to nor shall a person be subject to a penalty for failure to comply with a collection of information subject to the requirement of the Paperwork Reduction Act unless that collection of information displays a currently valid OMB control number.

# GLOBE 4th Grade Student Survey

## Form A
## Elementary School

**Name: ___________________________________________**

**Today's Date: _____/______/ 97  (month/day/year; example:  3/15/97)**

**My birthdate: _____/______/_____ (month/day/year)    Age: _______**

**I am a : _____ Boy          ______ Girl**

---

## Part I

***We want to know what students in the GLOBE program are doing and what they like and don't like about GLOBE.  Please tell us what you think by answering these questions.  Be sure to circle only ONE number for each statement.***

**1. How much do you like these parts of GLOBE?**

| | | Like it a lot | Like it a little | Do NOT like it | Our class does not do this |
|---|---|---|---|---|---|
| a. | Talking about weather, the earth, and water. | 1 | 2 | 3 | 9 |
| b. | Taking measurements for GLOBE. | 1 | 2 | 3 | 9 |
| c. | Putting GLOBE data on the computer. | 1 | 2 | 3 | 9 |
| d. | Looking at pictures taken by satellites. | 1 | 2 | 3 | 9 |
| e. | Looking at the GLOBE data collected by students in other places. | 1 | 2 | 3 | 9 |

2. **Think about the last week, from Monday through Friday. Circle a number to show whether YOU did each of these things last week.**

| | | Yes, I did it last week | NO, I did not do it last week | I'm not sure |
|---|---|---|---|---|
| a. | Took a measurement for GLOBE. | 1 | 2 | 9 |
| b. | Entered GLOBE data onto the computer. | 1 | 2 | 9 |
| c. | Compared a GLOBE measurement to data your class collected some time in the past. | 1 | 2 | 9 |
| d. | Talked about how something your class measures for GLOBE might change in the future. | 1 | 2 | 9 |
| e. | Helped other students work on GLOBE. | 1 | 2 | 9 |
| f. | Used the computer to send messages to students at another GLOBE school. | 1 | 2 | 9 |
| g. | Used the computer to send a message to a scientist. | 1 | 2 | 9 |
| h. | Talked to your parents or other adults about what you do in GLOBE. | 1 | 2 | 9 |
| i. | Wrote something about GLOBE. | 1 | 2 | 9 |

3. **Circle a number for each statement to show whether it is true or false.**

| | | True | False | I'm not sure |
|---|---|---|---|---|
| a. | I like doing GLOBE activities. | 1 | 2 | 9 |
| b. | Working with other students makes GLOBE more fun. | 1 | 2 | 9 |
| c. | GLOBE has taught me how to do more things with computers. | 1 | 2 | 9 |
| d. | It gets boring taking the same measurements over and over. | 1 | 2 | 9 |
| e. | I think the GLOBE project will help people understand the earth better. | 1 | 2 | 9 |
| f. | I don't know why we take the measurements we do for GLOBE. | 1 | 2 | 9 |
| g. | The measurements my class takes are important for scientists. | 1 | 2 | 9 |
| h. | What happens at one place on earth can make changes happen in other places. | 1 | 2 | 9 |
| i. | I like to study science. | 1 | 2 | 9 |
| j. | Scientists mostly just read books. | 1 | 2 | 9 |
| k. | Lots of times, you need math to do science. | 1 | 2 | 9 |
| l. | What we learn from science can help make our world a better place. | 1 | 2 | 9 |
| m. | I might want to be a scientist when I grow up. | 1 | 2 | 9 |
| n. | I like to use computers. | 1 | 2 | 9 |

4. **If someone in your class became a scientist, how much time would they spend doing the following?**

| | | A lot | Some | A little | None |
|---|---|---|---|---|---|
| a. | Using evidence to support their theory. | 1 | 2 | 3 | 4 |
| b. | Explaining the results of an experiment. | 1 | 2 | 3 | 4 |
| c. | Discussing their results with other scientists. | 1 | 2 | 3 | 4 |
| d. | Finding evidence showing how things happen in the world. | 1 | 2 | 3 | 4 |
| e. | Planning experiments and writing reports. | 1 | 2 | 3 | 4 |
| f. | Collecting data. | 1 | 2 | 3 | 4 |
| g. | Studying a problem without a clear solution. | 1 | 2 | 3 | 4 |
| h. | Using scientific evidence to prove that a theory is true or false. | 1 | 2 | 3 | 4 |
| i. | Defending their points of view or ideas. | 1 | 2 | 3 | 4 |

5. **Think about the things you do when your class is working on GLOBE. Circle a number to show how often you do each of these things as part of GLOBE.**

| | | Most of the time or always | Fairly often | Sometimes | Almost never or never |
|---|---|---|---|---|---|
| a. | I work in a group with other students. | 1 | 2 | 3 | 4 |
| b. | I write about what I have learned. | 1 | 2 | 3 | 4 |
| c. | I get mixed up about what I'm supposed to do. | 1 | 2 | 3 | 4 |
| d. | I use a computer. | 1 | 2 | 3 | 4 |
| e. | I help other students learn. | 1 | 2 | 3 | 4 |
| f. | I learn new words. | 1 | 2 | 3 | 4 |
| g. | I get bored doing something I don't care about. | 1 | 2 | 3 | 4 |
| h. | I use my head to figure out something. | 1 | 2 | 3 | 4 |
| i. | I answer questions from a book or worksheet. | 1 | 2 | 3 | 4 |
| j. | I learn how to do something important. | 1 | 2 | 3 | 4 |
| k. | I talk to my parents or other adults about what we're doing in GLOBE. | 1 | 2 | 3 | 4 |
| l. | I do something to improve the environment around my school or community. | 1 | 2 | 3 | 4 |

**OMB No. 0648-0310**
**Approval Expires: November 30, 1999**

# A SURVEY OF 7TH AND 10TH GRADE STUDENTS PARTICIPATING IN THE GLOBE PROGRAM

## GLOBE 7th and 10th Grade Student Survey

## Form A
## Middle and High School

**Name:** ________________________________________

**Today's Date:** ______/______/ 97 **(month/day/year)**

**Your birthdate:** _____/______/_____ **(month/day/year)** **Age:** _______

**Grade:** _____ 7th _____ 10th **Gender:** ______ Male ______ Female

---

## Part I

***We want to know what students in the GLOBE program are doing and what they like and don't like about GLOBE. Please tell us what you think by answering these questions.***

**1. When do you do GLOBE activities? (Circle the <u>one</u> best answer.)**

a. During a regular class or several classes
b. During free time, lunch period, club period, or after school
c. Both a. and b.

*Answer question 2 only if you do GLOBE activities during a regular class.*

**2. During what kind of class do you do your GLOBE work? (Circle ALL that apply.)**

a. Science class
b. Math class
c. Language Arts class
d. Social Studies class
e. Other (Give class name) ______________________________

**3. How much do you like these parts of GLOBE? Circle the appropriate number for each part.**

| | | Like a lot | Like a little | Do not like | Class doesn't do this |
|---|---|---|---|---|---|
| a. | Talking about weather, the earth, and water. | 1 | 2 | 3 | 9 |
| b. | Taking measurements for GLOBE. | 1 | 2 | 3 | 9 |
| c. | Putting GLOBE data on the computer. | 1 | 2 | 3 | 9 |
| d. | Using the visualization software to look at satellite images. | 1 | 2 | 3 | 9 |
| e. | Looking at the GLOBE data collected by students in other places. | 1 | 2 | 3 | 9 |

4. **Think about the LAST WEEK, from Monday through Friday. Circle the appropriate number to show whether YOU did each of these things last week.**

| | | I did this more than once | I did this one time | I did NOT do this |
|---|---|---|---|---|
| a. | Took a measurement for GLOBE. | 1 | 2 | 9 |
| b. | Listened to someone explaining how GLOBE data would be used by scientists. | 1 | 2 | 9 |
| c. | Entered GLOBE data onto the computer. | 1 | 2 | 9 |
| d. | Compared a GLOBE measurement to data your class collected some time in the past. | 1 | 2 | 9 |
| e. | Talked about how something your class measures for GLOBE might change in the future. | 1 | 2 | 9 |
| f. | Compared GLOBE data your class had collected to data from another GLOBE site. | 1 | 2 | 9 |
| g. | Created a spreadsheet or other record of GLOBE data. | 1 | 2 | 9 |
| h. | Helped other students work on GLOBE. | 1 | 2 | 9 |
| i. | Used the computer to send messages to students at another GLOBE school. | 1 | 2 | 9 |
| j. | Used the computer to send a message to a scientist. | 1 | 2 | 9 |
| k. | Talked to your parents or other adults about what you do in GLOBE. | 1 | 2 | 9 |
| l. | Wrote something about GLOBE. | 1 | 2 | 9 |

5. **If someone in your class became a scientist, how much time would they spend doing the following?**

| | | A lot | Some | A little | None |
|---|---|---|---|---|---|
| a. | Using evidence to support their theory. | 1 | 2 | 3 | 4 |
| b. | Explaining the results of an experiment. | 1 | 2 | 3 | 4 |
| c. | Discussing their results with other scientists. | 1 | 2 | 3 | 4 |
| d. | Finding evidence showing how things happen in the world. | 1 | 2 | 3 | 4 |
| e. | Planning experiments and writing reports. | 1 | 2 | 3 | 4 |
| f. | Collecting data. | 1 | 2 | 3 | 4 |
| g. | Studying a problem without a clear solution. | 1 | 2 | 3 | 4 |
| h. | Using scientific evidence to prove that a theory is true or false. | 1 | 2 | 3 | 4 |
| i. | Defending their points of view or ideas. | 1 | 2 | 3 | 4 |

6. **Circle the appropriate number for each statement to show whether you agree or disagree.**
(Scale: 1 = Strongly agree, 2 = Agree, 3 = Neither agree nor disagree, 4 = Disagree, 5 = Strongly disagree)

| | | | | | | |
|---|---|---|---|---|---|---|
| a. | I like doing GLOBE activities. | 1 | 2 | 3 | 4 | 5 |
| b. | Working with other students makes GLOBE more fun. | 1 | 2 | 3 | 4 | 5 |
| c. | GLOBE has taught me how to do more things with computers. | 1 | 2 | 3 | 4 | 5 |
| d. | It gets boring taking the same measurements over and over. | 1 | 2 | 3 | 4 | 5 |
| e. | I think the GLOBE project will help people understand the earth better. | 1 | 2 | 3 | 4 | 5 |
| f. | I don't know why we take the measurements we do for GLOBE. | 1 | 2 | 3 | 4 | 5 |
| g. | The measurements my class takes are important for scientists. | 1 | 2 | 3 | 4 | 5 |
| h. | What happens at one place on earth can make changes happen in other places. | 1 | 2 | 3 | 4 | 5 |
| i. | Scientists mostly just read books. | 1 | 2 | 3 | 4 | 5 |
| j. | Lots of times, you need math to do science. | 1 | 2 | 3 | 4 | 5 |
| k. | What we learn from science can help make our world a better place. | 1 | 2 | 3 | 4 | 5 |
| l. | After doing GLOBE, I am more interested in taking science classes. | 1 | 2 | 3 | 4 | 5 |
| m. | I might want to be a scientist. | 1 | 2 | 3 | 4 | 5 |
| n. | I like to use computers. | 1 | 2 | 3 | 4 | 5 |

7. **Think about the things you do when your class is working on GLOBE. Circle the appropriate number to show how often you do each of these things as part of GLOBE.**

| | | Most of the time or always | Fairly often | Sometimes | Almost never or never |
|---|---|---|---|---|---|
| a. | I work in a group with other students. | 1 | 2 | 3 | 4 |
| b. | I write about what I have learned. | 1 | 2 | 3 | 4 |
| c. | I get mixed up about what I'm supposed to do. | 1 | 2 | 3 | 4 |
| d. | I use a computer. | 1 | 2 | 3 | 4 |
| e. | I help other students learn. | 1 | 2 | 3 | 4 |
| f. | I learn new words. | 1 | 2 | 3 | 4 |
| g. | I get bored doing something I don't care about. | 1 | 2 | 3 | 4 |
| h. | I think of my own idea for how to solve a problem. | 1 | 2 | 3 | 4 |
| i. | I answer questions from a book or worksheet. | 1 | 2 | 3 | 4 |
| j. | I work on a science problem that is like a real-life problem I care about. | 1 | 2 | 3 | 4 |
| k. | I talk to my parents or other adults about what we're doing in science. | 1 | 2 | 3 | 4 |
| l. | I do something to improve the environment around my school or community. | 1 | 2 | 3 | 4 |