GLOBE YEAR 3 EVALUATION

Implementation and Progress

December 1998

Prepared for:

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

The Year 3 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.

SRI International

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Executive Summary

Students, teachers, and scientists from around the world are collecting, sharing, and analyzing data about the Earth as part of Global Learning and Observations to Benefit the Environment (GLOBE), an international environmental science research and education program.

Since its inception in 1994, GLOBE has been run by an interagency program office based in Washington, D.C., with involvement and support 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.

The GLOBE program is intended to meet three primary goals:

- *To contribute to scientific understanding of the Earth;*
- *To help all students reach higher levels of achievement in science and mathematics; and*
- *To enhance the environmental awareness of individuals throughout the world.*

As GLOBE participants, students make observations at study sites at or near their schools and then enter their data on the World Wide Web. Through the Web, students can (1) view global images based on the entire GLOBE student database, (2) interact with scientists who use their data in conducting research, and (3) communicate and participate in joint research with other students from around the world.

The GLOBE program provides a set of protocols for data collection in four investigation areas: Atmosphere, Hydrology, Soil, and Land Cover/Biology. The protocols specify GLOBE's requirements for data collection, including times when measurements are to be taken, the instruments needed, and procedures to ensure accuracy of data and consistency across study sites. In addition to specifications for the measurement protocols, the GLOBE Teacher's Guide contains related learning activities for classroom use. Although the data collection protocols must be used by all participants, the program gives teachers the freedom to choose whatever learning activities they believe will best support their students' learning. The learning activities are designed to help students understand the scientific context of their data collection activities, to encourage student analysis of GLOBE data, and to promote original inquiry.

Unlike traditional school science programs, in which students perform isolated experiments with no consequences for increasing scientific knowledge of the world, GLOBE has teachers and students participate in actual science investigations led by scientists selected through a competitive grant process. Through participation in the program, students have many opportunities to interact with scientists and contribute their data to actual scientific research. In addition, students generate their own questions, working with other students at their school or at other GLOBE schools to conduct investigations and share their findings via the Internet.

Before their students can enter data on the GLOBE database, teachers must complete a training program in which they learn how to conduct the GLOBE protocols and gain experience with the learning activities in the GLOBE Teacher's Guide. By fall 1998, teachers from over 5,500 schools in more than 70 countries had gone through GLOBE teacher training. Interdisciplinary teams including scientists, educators, and technology specialists conduct the GLOBE teacher training workshops over a period of 3 to 4 days at regional sites throughout the United States and at selected locations around the world.

Two years ago, the United States GLOBE program began entering into partnerships with other U.S. organizations, such as universities and school districts, to recruit, train, and mentor GLOBE teachers within their areas. These GLOBE "franchises," as they are called, have grown in number as interest in the program has increased, and in 1998 more teachers received GLOBE training through franchises than from GLOBE contract trainers.

Outside the United States, GLOBE provides a basic program infrastructure, and the international partner countries manage their own implementation of the program, acquiring the resources necessary to equip their own schools. The partner countries select coordinators and schools, and determine their own implementation plans.

Once trained, GLOBE teachers have the opportunity to collaborate with one another in the program, both within their school and with other GLOBE sites via the Internet. In the past 2 years, GLOBE has encouraged schools to have multiple teachers participate in the program. The team approach is intended to make consistent data collection easier, facilitate the sharing of ideas for learning activities, and increase the likelihood that the program will be sustained over time.

The Evaluation

SRI International was selected through a competitive grant process to provide GLOBE's evaluation component. This report focuses on evaluation activities and findings from 1997-98, the third school year of GLOBE implementation. Earlier findings from Year 1 and Year 2 evaluation are used to provide a context for interpreting the Year 3 data.

A major component of the Year 3 evaluation was a teacher survey administered in the spring of 1998 to a randomly selected sample drawn from the population of teachers who completed GLOBE training between June 1996 and December 1997. (This training window was chosen because the new Teacher's Guide with GLOBE II materials was introduced in training in June 1996.) Because of the increasing importance of franchises in providing GLOBE training to U.S. teachers, we also drew a second sample of 120 teachers who had received their training from franchises. Overall, 66% of the teachers in the combined survey sample responded, for a total of 378 respondents, including 51 teachers outside the United States and 81 teachers trained by a U.S. GLOBE franchise.

In addition to the activities of data-reporting classrooms, the survey addressed implementation barriers and issues with the goal of providing insights into the experiences of (1) teachers who had received GLOBE training but had not implemented the program and (2) teachers who used GLOBE activities and materials but reported little or no data.

The evaluation team also conducted site visits to four U.S. GLOBE schools representing a range of implementation models and grade levels. These visits, conducted between December 1997 and April 1998, included interviews of GLOBE teachers, observations of GLOBE activities (including accompanying students to data collection sites), informal discussions with students, and, where appropriate, interviews with administrators who had been most involved in getting the program started within the school. In addition, we pilot tested an open-ended interview technique designed to elicit students' thinking about the environment to see whether we could use such an instrument in later data collections to evaluate GLOBE's impact on environmental awareness.

The Findings

When asked to describe their involvement with GLOBE during the 1997-98 school year, 65% of our survey respondents said that they had implemented the program with students. Teachers in our survey sample who did not implement the program with students during 1997-98 were asked to indicate the barriers preventing them from using the program. The barrier cited as "major" by the largest proportion of teachers (52%) was finding a way to collect data when school is not in session (i.e., on weekends and during vacations). The second most frequently cited major barrier was lack of Internet access. Despite the dramatic increase in the proportion of U.S. classes with Internet access, 49% of the teachers who had not implemented the program with students cited lack of access as a major obstacle.

After lack of Internet access, the next three barriers in decreasing order of importance all concerned time:

- The time needed to plan and set up for the program (cited as major by 47%).
- Finding time, given other curricular and testing requirements (46%).
- Finding long enough blocks of time within the school schedule (41%).

Fitting GLOBE into the existing curriculum was viewed as a major barrier by 34% of the teachers who had taken the training but not yet implemented the program with students.

A positive sign for the program is that a very small fraction of the teachers (4%) who had failed to implement the program by the spring of 1998 cited concern about GLOBE's value for their students as a major barrier. Moreover, 84% of these nonimplementers reported that they expected to implement GLOBE with their students at a future time.

Teachers who had not begun implementing GLOBE with students were asked also what actions the GLOBE program could take to increase the likelihood that they would implement the program with their students. Funding for GLOBE equipment was the most desired support in the eyes of these teachers (56% of whom said it would be a "big help"). The next most highly rated potential supports were all mechanisms for increasing these GLOBE-trained teachers' skills and confidence that they know how to execute the measurement protocols correctly:

- Videotapes on how to conduct GLOBE protocols (considered a big help by 49%).
- Contact and coaching from a GLOBE trainer in their local area (45%).
- Additional or refresher training through the World Wide Web (39%).
- Contact with local GLOBE teachers (33%).
- Additional face-to-face training (32%).
- Contact with scientists on how to conduct the GLOBE protocols (28%).

Those survey respondents who did implement the program with students in 1997-98 provided a portrait of the great diversity of settings in which GLOBE was implemented. Roughly one-third of GLOBE teachers implemented the program at the elementary level, one-third at the middle school or junior high level, and one-third at the high school level (more precisely, 35%, 36%, and 29%, respectively). International GLOBE teachers were less likely than U.S. teachers to be working within elementary settings. GLOBE was most often conducted as part of a regular class, but 13% of teachers conducted their GLOBE activities through pull-out programs, clubs, or lunch programs. When GLOBE was offered within elementary school classes, it was usually in a regular general elementary classroom rather than a special class taught by a science specialist. The middle- and secondary-level classes where GLOBE was most commonly taught were Earth/space science, environmental science, and general science (20%, 16%, and 14%, respectively, of the middle and secondary school classes within which GLOBE was conducted).

Just over half of the U.S. teachers in our survey sample reported being the only teacher implementing GLOBE in their schools. In the 1996 survey of a representative sample of GLOBE-trained teachers, the proportion who reported implementing GLOBE alone was 72%, suggesting that there has been a shift toward having multiple teachers within a school involved in GLOBE. Around 30% of implementing teachers in the 1998 survey said they were one of two GLOBE teachers at their school, 9% one of three, and 6% one of a larger number of teachers.

Teachers were asked to indicate which components of GLOBE they had implemented with students in school year 1997-98. Virtually all of the teachers who said on the survey that they had implemented GLOBE with students reported having their students collect data. Not all of the teachers whose students collected data had the students report them to the GLOBE Student Data Archive, however; 24% of GLOBE teachers whose students collected data said that their students did not put data into the computer. Seventy-two percent of GLOBE-implementing teachers reported having done GLOBE learning activities with their classes during 1997-98. Thus, the proportion of teachers having their students engage in GLOBE learning activities is now very similar to that having students submit data. This represents a shift from the first year of the program, when more emphasis was given to collecting data than to the learning activities that provide a context for the measurements. Year 3 survey responses suggest also that teachers are giving more emphasis to analyzing and interpreting GLOBE data: 62% of GLOBE-implementing teachers reported that they had students analyze, discuss, or interpret the data. Forty-four percent reported having had their students explore information on the GLOBE Web site.

Teachers who implemented GLOBE with students were asked to indicate which protocols and learning activities they had used. There were dramatic differences in implementation rates for different investigation areas. Ninety-five percent of GLOBE elementary teachers and 88% of teachers at the middle and secondary levels implemented one or more Atmosphere protocols. One or both GPS protocols were implemented by 55% of GLOBE teachers at all school levels. One or more Hydrology protocols were implemented by 26% of elementary and 40% of middle and secondary teachers. Fewer than 20% of teachers at either school level implemented one or more protocols in either Land Cover/Biology or Soil.

The pattern of implementation rates for learning activities was similar to that for protocols. Ninety-two percent of elementary GLOBE teachers and 85% of middle and secondary teachers implemented one or more Atmosphere learning activities. In contrast, just 31% of elementary teachers and 35% of middle and secondary teachers implemented one or more Hydrology learning activities. The likelihood of implementing one or more learning activities was even smaller for the other investigation areas, but it is worth noting that within both the Soil and the Hydrology investigations, elementary teachers were more likely to implement learning activities than protocols.

In addition to describing how they implemented GLOBE, teachers were asked to rate the extent to which GLOBE had improved their students' skills and knowledge in specific areas. Overall, GLOBE teachers viewed the program as very effective. Teachers reported the greatest gains in the areas of observational skills, measurement skills, ability to work in small groups, and technology skills. More than two-thirds (68%) of the GLOBE-implementing teachers in our survey sample reported that their students' observational skills had increased "very much," 56% reported similar gains in measurement skills, 50% reported a "very much" increased ability to work in small groups, and 40% reported an increase in students' technology skills. The perceived student gains were greater among teachers who implemented GLOBE learning activities or who had their students analyze and interpret GLOBE data (75%, 64%, 57%, and 45% reporting that their students' skills had increased "very much" in the four areas).

The largest perceived student knowledge gain was in knowledge about Atmosphere (69% thought their students' knowledge had increased "very much"), followed by GPS (41%) and Hydrology (36%).

In addition to these teacher reports of student knowledge gains, the evaluation team obtained examples of student thinking during site visits. In the environmental awareness pilot study, small groups of students from six GLOBE classes and two non-GLOBE science classes were shown a complex natural scene and asked to describe the ecology suggested by the picture. GLOBE students' statements included a larger proportion of higher-level inferences concerning underlying ecological themes such as interdependence, adaptation, and cycles. GLOBE students also required less prompting than did non-GLOBE students to elicit inferences about the environment.

Emerging Issues

Each year, the evaluation team has highlighted issues for GLOBE to consider as the program continues to evolve and refine its support structure. Many program changes over the past 2 years have addressed issues highlighted in earlier reports. The issues underlying the data collected in Year 3 are similar in many ways to those described earlier. In some cases, changes undertaken by GLOBE have not yet worked their way through the system to implementation in a majority of settings. In other cases, the problems are fundamentally very difficult ones, which will require continued management attention and multiple, creative approaches.

Increasing the number of types of data reported by individual sites. A large proportion of GLOBE schools are using only the Atmosphere investigation. Atmosphere is appealing to teachers both because it relates to weather concepts that are part of many curricula and because the instrumentation for the protocols is relatively straightforward to use. A fuller picture of the Earth requires consideration of the soil, land cover, and water as well as the air, however. Experience with the program to date suggests that the emphasis on non-atmosphere investigations in training and follow-up contact with teachers needs to be very strong and that the concepts and protocols need to be presented more clearly and simply for teachers with limited science backgrounds.

Obtaining more consistent, continuous data sets. If GLOBE is to fulfill its science objective, there need to be more sites adhering to a consistent data collection protocol over the long term. Sharing strategies for collecting data on weekends and during school breaks and other interruptions is one effort in this direction. But dissemination of such strategies will do little good unless there are individuals with a strong motivation to use them. Stronger support for and greater interaction with local GLOBE franchises and increased communication with scientists are being explored as strategies for addressing this concern.

Dealing with teacher turnover. National statistics indicate that at the end of each school year, approximately 13% of teachers will leave the school at which they have been teaching (either to move to another school or to leave the profession). Recognition of this fact of school life was one of the motivations behind the program's recommendation that multiple teachers be trained from each school. Nevertheless, we know that there are many schools with only a single trained teacher and that when that teacher leaves, the GLOBE program may either cease to exist or be turned over to a teacher with no formal GLOBE training. Mechanisms need to be in place to "recapture" GLOBE schools that have lost their trained teacher.

Maintaining the quality of teacher training and teacher implementation. As the GLOBE program continues to grow, GLOBE franchise and international partners are likely to be leaders in developing strategies for maintaining program quality. More ongoing contact with trainers and scientists is one important support. Other options include designating master or mentor teachers, who then provide technical assistance, feedback, and coaching for other GLOBE teachers, either in person or over an electronic network. (Franchises, districts, or schools would need to find funding for stipends or release from all or a portion of regular teaching duties for these teachers.)

Improving content integration. Although the GLOBE materials have improved considerably from the first Teacher's Guide in terms of the amount of cross-referencing across investigation areas, the materials are still not as well integrated as one would like. The next edition of the Teacher's Guide, to be released in 2000, will include an integrating Earth Systems investigation to highlight the interdependencies among the

Earth's land cover, atmosphere, water, and soil. Even so, the Teacher's Guide materials could be refined to better stress skills, such as sampling and data analysis, and "big ideas," such as cycles and adaptation, that cut across the individual investigation areas. We recommend convening a panel of science curriculum advisors to review and address this issue now as the new materials are being developed.

Increasing personal interactions with the science community. Interactions with working scientists are an important aspect of GLOBE's appeal for students and teachers. Data continuity and quality issues could be ameliorated with a further increase in the amount of personal involvement and communication, not only with the science PIs themselves but also with others working within their laboratories (e.g., graduate students) and in their spheres of influence. Soil PI Elissa Levine's fall 1998 offer of a sample of Bolivian soil from the site of a possible meteor crater impact for all GLOBE schools with completed Soil Characterization protocols is an example of the kind of interaction that can motivate broader implementation of GLOBE.

Conclusion: GLOBE in Perspective

Contributing to the scientific understanding of the Earth is one of GLOBE's primary goals, and GLOBE scientists are in the process of formulating plans for using GLOBE data. Several of the investigators are negotiating with Earth Observing System (EOS) teams to compare GLOBE land cover and surface temperature data with that collected by satellites. Another GLOBE scientist plans to use GLOBE data for phenology (bud burst) studies.

Although it is too soon to judge whether GLOBE will make significant contributions to the scientific knowledge base, it is clear that GLOBE scientists have become increasingly involved with students and teachers. That involvement is moving beyond broadcasting messages to include instances of real collaboration, with ensuing benefits for both sides. Interactions with schools enable scientists to see how their investigations are being conducted, to acquire a better understanding of the kind of inquiry needed to sustain students' motivation, and to develop a more realistic understanding of the nature of schools. Several scientists have suggested also that it has pushed them to take a fresh, more interdisciplinary look at their fields of study. Students and teachers benefit from the scientists not only as sources of knowledge and modelers of scientific reasoning but also as inspiration and role models for students who may choose to pursue careers in science or technology.

At this stage of the program's evolution, more evaluation evidence is available concerning GLOBE's progress toward its second goal, supporting student learning in science and mathematics. Both observations of GLOBE students' activities and structured assessments of student knowledge (i.e., the comparative study of GLOBE and non-GLOBE classrooms conducted in Year 2) suggest that GLOBE can have a positive impact on students' ability to collect and interpret scientific data in classes where the program is implemented to a significant degree.

GLOBE's third goal, increasing environmental awareness, has been less straightforward to define and measure. In Year 2, the evaluation found that GLOBE and non-GLOBE students were similar in terms of expressions of positive attitudes toward the environment. Concurrently, we realized that GLOBE's framers conceived of environmental awareness not so much as interest in or concern about environmental issues per se but rather as a scientific awareness of the natural environment. In Year 3, the evaluation included the development of an interview technique for assessing the extent to which GLOBE has given students a more differentiated, deeper understanding of the natural world. Our pilot findings are positive. GLOBE students appear to make more science-based, higher-level inferences about the natural world than do their non-GLOBE peers. In Year 4, we will administer more structured assessments of environmental awareness to larger samples of GLOBE and non-GLOBE students.

GLOBE is an ambitious attempt to put the concepts of authentic learning, student-scientist partnership, and inquiry-based pedagogy into practice on an unprecedented scale. The evaluation findings suggest that when well implemented by skilled teachers, GLOBE has a positive impact on students' ability to *do* science and interpret scientific data. To fulfill its mission, the program wants to increase the number of schools implementing GLOBE with enough intensity to reap these benefits. GLOBE's ability to make further progress on both its educational and its scientific goals is likely to hinge on the quality of the supports provided for local program implementation.

Chapter 1. Introduction

Global Learning and Observations to Benefit the Environment (GLOBE), an international environmental science research and education program, involves students, teachers, and scientists from around the world in collecting, sharing, and analyzing data about Earth's dynamic land, air, water, and biology systems. GLOBE activities are organized around three primary objectives:

- To contribute to scientific understanding of the Earth;
- To help all students reach higher levels of achievement in science and mathematics; and
- To enhance the environmental awareness of individuals throughout the world.

As GLOBE participants, students make observations at or near their schools in one or more of four investigation areas: Atmosphere, Hydrology, Soil, and Land Cover/Biology. They then enter their data on the World Wide Web, where they can view global images based on the entire GLOBE student database and interact with scientists who use their data in conducting research. GLOBE scientists help students understand the context as well as the importance of their data for the advancement of environmental science.

GLOBE is run by an interagency program office based in Washington, D.C., with involvement and support 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.

The GLOBE program provides both a set of protocols for data collection in the four investigation areas and structured learning opportunities for teachers to use in their classrooms. The protocols specify GLOBE's requirements for data collection, including times when measurements are to be taken, the instruments needed, and procedures to ensure accuracy of data and consistency across study sites. Although the data collection protocols must be used by all participants, the program gives teachers the freedom to choose whatever learning activities they believe will best support student learning. The learning activities are designed to help students understand the scientific context of their data collection activities, to encourage student analysis of GLOBE data, and to promote original inquiry.

The GLOBE learning model is consistent with inquiry and collaborative learning approaches advocated in contemporary school reform initiatives. More conventional school science programs have been criticized for their treatment of scientific disciplines as isolated, static domains of knowledge that are given broad but superficial treatment in classrooms. In response, organizations such as the National Science Foundation and the National Research Council have called for science programs that encourage students to work collaboratively with their peers and teachers to develop both deeper content knowledge and process skills, including asking their own questions and developing explanations backed by well-reasoned uses of scientific data.

The GLOBE program addresses many of these concerns in its program design, which includes a “community of learners” (Brown & Campione, 1994) philosophy that calls for adults and students to work together to build scientific knowledge. Unlike traditional school science programs, in which students perform isolated experiments with no consequences for increasing scientific knowledge of the world, GLOBE has teachers and students participate in actual science investigations led by scientists selected through a competitive grant process. Through participation in the program, students have many opportunities to interact with scientists and contribute their data to actual scientific research. In addition, students generate their own questions, working with other students at their school or at other GLOBE schools to conduct investigations and share their findings via the Internet.

Prospective GLOBE teachers undergo a rigorous training program that is aimed at introducing the teachers to the data collection protocols and learning activities in each of the investigation areas. By fall 1998, teachers from over 5,500 schools in more than 70 countries had gone through GLOBE teacher training. Working under contract to GLOBE, interdisciplinary teams including scientists, educators, and technology specialists conduct GLOBE teacher training workshops lasting 3 to 4 days at regional sites throughout the United States and at selected locations around the world

Two years ago, the United States GLOBE program began entering into partnerships with other U.S. organizations, such as universities and school districts, to recruit, train and mentor GLOBE teachers within their areas. These GLOBE “franchises,” as they are called, have grown in number as interest in the program has increased. Outside the United States, international partner countries manage their own training programs.

Once trained, GLOBE teachers have the opportunity to collaborate with each other in the program, both within their school and with other GLOBE sites via the Internet. In the past 2 years, GLOBE has encouraged schools to have multiple teachers participate in the program. The team approach can make consistent data collection easier, facilitate the sharing of ideas for learning activities, and increase the likelihood that the program will be sustained over time. A teacher listserv is available for exclusive use by GLOBE teachers. A section of the GLOBE Web site is dedicated to presenting resources that have been identified by participants as useful teaching and learning tools.

Program Growth

In November 1996, after the GLOBE program completed its first year of training using the original Teacher's Guide, teachers were issued a second-edition guide with a greatly expanded set of protocols and learning activities (sometimes called "GLOBE II"). Subsequently, additional changes were made and a 1997 guide supplement was issued. The supplement included expanded versions of some of the existing protocols, as well as several new data collection protocols. The supplement also contained additional learning activities. Table 1.1 shows the 29 GLOBE data collection protocols in effect after the distribution of the 1997 supplement. The survey instrument used in our Year 3 evaluation reflects the content of the 1997 supplement as well as the second edition of the Teacher's Guide, but it should be noted that, at the time of our survey, many of the changes and additions contained in the supplement had not yet permeated significant numbers of GLOBE classrooms.

International Partners

From the first, GLOBE was designed as an international program "involving as many countries as possible that will use school teachers and their students to monitor the entire earth" (Gore, 1992). Vice President Gore sent letters to heads of government in countries around the world inviting them to join the GLOBE program. In November 1994, GLOBE educators and educators from GLOBE partner countries around the world met in Washington, D.C., to discuss the development of the educational materials to be used in conjunction with the GLOBE science protocols and to review environmental education materials used in partner countries for their possible inclusion in the GLOBE materials.

Table 1.1

GLOBE Data Collection Protocols, as of 1997

Atmosphere Investigation	*GPS Investigation*
Min/Max/Current Temperature	GPS
Rainfall	Offset GPS***
Solid Precipitation	
Precipitation pH *	
Cloud Cover	
Cloud Type	
Hydrology Investigation	*Soils Investigation*
Water Temperature	Soil Characterization Field Measurements **
Water pH	Soil Characterization Lab Analysis **
Water Transparency *	Gravimetric Soil Moisture **
Salinity *	Infiltration *
Optional Salinity Titration *	Soil Temperature *
Dissolved Oxygen	
Alkalinity **	
Electrical Conductivity	
Nitrate *	
Land Cover/Biology Investigation	
Qualitative Land Cover Sample Site**	
Quantitative Land Cover Sample Site**	
Biometry**	
MUC System**	
Manual Interpretation Land Cover Mapping**	
Unsupervised Clustering Land Cover Mapping**	
Accuracy Assessment	

* New in 1997 supplement.

** Modified in 1997 supplement.

*** Formerly a learning activity.

By June 1995, 113 of 183 invited countries had expressed an interest in joining GLOBE. 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.

Despite the high level of international interest from GLOBE's inception, it took time for international partners to identify the funding, organizational supports, school participants, and needed equipment. In GLOBE's early years, most schools whose participation included reporting data were located in the United States (80% in May 1996, for example). Over time, however, GLOBE has become increasingly international in practice as well as in intent. Starting from a base of 173 schools contributing data from 19 countries outside the United States in school year 1995-96, international participation grew to 847 non-U.S. schools in 44 countries by October 1998.

Program Refinements

The Year 2 evaluation (Means et al., 1997) identified seven issues for discussion and improvement:

- Increasing the proportion of schools with 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."

As the GLOBE program has continued to evolve, it has taken steps to address these issues.

Increasing the Likelihood of Full Implementation. This difficult challenge is being addressed through the multiple-teacher or "community of learners" model for implementation. It is believed that collectively, through sustained inquiry, students and teachers are able to generate more information and data than would be possible from the efforts of any individual alone. This approach enables multiple teachers from each school to receive GLOBE training so that when they return to their classrooms, they are more able to help each other implement the program at their school. By distributing the work among several teachers at a single site, more data are likely to be collected and understood across a wider range of grades and in varying contexts. Also, the program becomes less susceptible to abandonment caused by teacher turnover. This model requires collaboration among GLOBE teachers, a practice that is often promoted in school reform efforts. Although teachers are traditionally responsible for developing student learning in their own classrooms, it is rare for them to be given opportunities to work together to support the learning and teaching of themselves and their colleagues. GLOBE's team approach can provide such an opportunity.

Supporting Implementation at a Variety of Grade Levels. In developing additional learning activities and protocols for the 1997 Teacher's Guide Supplement, scientist-educator teams were instructed to develop materials appropriate for primary (K-3) and secondary grades. In addition, a new round of GLOBE grants awarded in May 1998 included a grant exclusively focused on developing materials for the early grades.

Preparing and Incentivizing Teachers to Try Out New Protocols and Activities. When asked to rate how well their training prepared them to implement the data collection protocols in the various investigations, GLOBE teachers express much greater confidence in the adequacy of their preparation for doing protocols in Atmosphere than in any of the other areas (see Chapter 5). The GLOBE program has sought to improve training, making investigations besides Atmosphere more easily understood. In addition, it is believed that the same multiple-teacher model that is expected to support broader, more sustained implementation will also increase the proportion of teachers trying out new protocols. It is believed that teachers new to GLOBE will be more likely to try out new protocols and learning activities when they have the added incentive, support, and knowledge that are developed through collaboration with their colleagues. As teachers work together to implement GLOBE at their schools, they will soon have the option of using GLOBE-developed videotapes on how to take the GLOBE measurements. Nineteen videotapes are being developed under contract, and the first set of tapes (for

Hydrology) will be released in 1999. The videos are intended for use by teachers when they return to their schools after training.

Supporting Teachers in Training Their Colleagues. If a GLOBE teacher inspires some of his or her colleagues to join the program, GLOBE encourages the new teachers' participation in training offered at GLOBE contract training sites or one of the franchises. The program views on-site support from colleagues as a supplement to rather than a replacement for the formal GLOBE training. Even so, the increasing availability of training and resource materials on the GLOBE Web site and in the new videos will not only help teachers improve their own skills but also enhance the level of support they can provide for their colleagues.

Sustaining School Interest and Involvement over Time. The thinking behind developing regional training franchises is that franchise partners can not only stretch the resources available for teacher training but also provide more support to trainees through ongoing local contacts than would be possible in a national training system. To develop a franchise, an entity such as a university, school system, consortium, or entire state signs a joint agreement with NOAA (representing GLOBE) to recruit, train, and mentor GLOBE teachers within its area. After a franchise agreement is negotiated, GLOBE trains the franchise's trainers and makes sure that the necessary science, education, and systems support infrastructures are in place. Franchises sign a memo of understanding that they will use the official GLOBE materials and training procedures. It was felt that creating local and distributed franchises would (1) stimulate local and regional interest in GLOBE, (2) make it possible for the program to grow within the United States without increasing the level of federal investment, and (3) provide a higher level of ongoing support and follow-up contact to the GLOBE teachers. For these reasons, it is believed that the franchises will be better able to sustain school interest and keep schools involved in the GLOBE program over time. Too few teachers had "graduated" from franchise training to permit an empirical test of this assumption in Year 3. As of fall 1998, however, 86 franchise agreements have been negotiated and more than 1,850 teachers have been franchise trained. Future evaluation activities will test the hypothesis that teachers receiving ongoing support from franchises participate in GLOBE more fully and over longer periods of time than teachers receiving training at a contract training site.

Supporting Classroom Assessment. Recognizing that more could be done to equip teachers with tools for examining what their students are learning through GLOBE, the program included a grant for developing classroom assessments in its latest round of GLOBE grants. The project to design student assessment tools aims to support GLOBE teachers' instructional decision-making by assessing students' deep understanding of GLOBE concepts and their ability to conduct and interpret GLOBE investigations. Student assessment tools will include tests of taking GLOBE measurements according to the protocols and tasks eliciting a range of scientific inquiry strategies, such as investigation planning, comparisons and interpretations of GLOBE data within and across schools, communication about the investigations, and collaboration skills.

Monitoring Quality of Training. GLOBE has expanded both the amount of information collected from teachers as they complete their training and the usability of that teacher feedback. Following each teacher training session, teachers respond to a survey to indicate their beliefs about the effectiveness of many aspects of the training. The information from these surveys is entered into a new GLOBE database as part of the overall effort to monitor the quality of the training provided. Future evaluation activities will include linking the database of end-of-training survey responses to the Student Data Archive to examine links between training variables and breadth and duration of participation.

Overview of This Report

As the GLOBE program has evolved, so has the evaluation. Over the 3 years of evaluation activities, issues have been raised, changes implemented, and new concerns and opportunities emerged. This report summarizes findings from our Year 3 data collection and provides reflections both on those findings and on the evaluation results for the entire 3 years of GLOBE's history. Our data were collected during school year 1997-98. We have included a description of some of the program changes that were made during that period, but it should be noted that many of the refinements put in place during 1997-98 (notably the growth of a large number of GLOBE training franchises and new learning activities in the 1997 Guide Supplement) were not yet affecting significant numbers of GLOBE classrooms at the time of our data collection.

The data collection and analysis methods used in the evaluation are described in Chapter 2. Chapter 3 provides documentation of the program's growth in terms of teachers trained and data reported. Chapter 4 concerns 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 interviews with franchise and international partners. Chapter 6 discusses evidence for program influences on students, including a pilot study examining environmental awareness. Scientists' involvement with GLOBE and their perspective on GLOBE's potential for contributing to science are discussed in Chapter 7. Finally, Chapter 8 provides a synthesis of the preceding chapters and earlier evaluation reports, with issues for future program improvements.

Chapter 2. Overview of Evaluation Methodology

SRI International was selected through a competitive grant process to provide GLOBE's evaluation component. This report focuses on evaluation activities and findings from 1997-98, the third school year of GLOBE implementation. In this chapter, we provide an overview of the data sources and methodology applied in our third-year evaluation activities.

The three main sources of information used—databases developed by GLOBE and our own teacher 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. 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. The database was enhanced during 1997-98 to permit linking with the GLOBE Student Data Archive and includes additional elements such as grade level taught, location of GLOBE training, and tracking of the activity status of trained teachers.

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 calculating the number of schools reporting data during each month of the 1997-98 school year, the frequencies with which various data categories were reported, and the frequency distribution of school data reports, all presented in the next chapter.

Teacher Surveys

Information on just how GLOBE is being implemented, the challenges involved in implementation, and the perceived effects on students were derived from a teacher survey conducted during March-June 1998. The full text of the teacher survey is available in the Appendix. The surveys were made available in both hard-copy form and on the World Wide Web. Many of the items on the survey had been used in prior years, permitting us to track the evolution of GLOBE teacher experiences and perceptions over time.

In contrast to Year 2 of the evaluation, when we focused both the Teacher Survey and a Student Assessment component on schools that were active in reporting data to the GLOBE Student Data Archive, our Year 3 evaluation focused on assessing the experiences of a representative sample of teachers trained in GLOBE. In Year 3, we wanted to add to our understanding of the concerns and barriers involved for teachers who received GLOBE training but had not implemented the program, and to understand the nature of the activities in classrooms using GLOBE materials but reporting few or no data to the Data Archive. Accordingly, we selected a simple random sample from the population of teachers who received GLOBE training between June 1996 and December 1997. (This training window was chosen because the new Teacher's Guide with GLOBE II materials was introduced in training in June 1996.)

Because of the increasing importance of franchises in providing GLOBE training to U.S. teachers, we also drew a second sample of 120 teachers who had received their training from franchises. For purposes of this report, responses from franchise-trained teachers are included with those of other GLOBE teachers. We did, however, run preliminary analyses contrasting franchise-trained teachers to other U.S. teachers and found very few statistical differences on any of the measures.

International partner teachers were also selected at random and in the same proportion as for U.S. nonfranchise teachers. Table 2.1 lays out the population of teachers trained within our chosen time frame and the target samples.

For U.S. teachers, the survey procedures were the same as those used in 1996 and 1997. A letter announcing the upcoming survey and explaining its purpose went out to all U.S. teachers to be surveyed in early March 1998. SRI mailed printed copies of the surveys on March 16. 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 7, nonrespondents were sent reminder postcards. On April 17, a letter from Tom Pyke, the GLOBE Director, urged remaining nonrespondents to send in their surveys. An additional reminder letter was sent from SRI on April 28 to non-respondents. During May and into early June, attempts were made to reach nonrespondents by telephone. On June 15, the instrument was taken off the Web, and no further follow-up attempts were made.

Table 2.1
Year 3 Teacher Survey Populations and Sample Sizes
(Percent Reporting)

	Population	*Target Sample*	*Population in Sample*
U.S. franchise trained	169	120	71
U.S. other	1,851	315	17
International	811	140	17
Total	2,831	575	20

International teachers' surveys and instructions were sent to country coordinators on March 18 by SRI. Coordinators sent the surveys to the specified teachers, and those teachers either completed the survey on the Web, mailed their survey back to SRI directly by using a business reply envelope, or sent their survey to the coordinator to batch and return. Beginning in April, Lyn Wigbels, GLOBE Assistant Director for International Programs, asked the country coordinators to urge the nonrespondents to send in their surveys. Spring 1998 was the first time international teachers were given the option of completing the Teacher Survey on the World Wide Web (as several had urged in 1997). We noted that the likelihood of choosing to respond electronically was higher for international than for U.S. teachers, as shown in the last column of Table 2.2.

Table 2.2 displays the samples, response rates, and effective samples for the teachers we surveyed. As the table indicates, a strong response rate was achieved for U.S. teachers (combined rate of 75%), but the response rate for GLOBE teachers outside the United States was only 36%. In preliminary data analyses, we disaggregated the data according to U.S. vs. other nationalities, and some significant differences were noted. However, the response rate for international teachers is low enough to suggest caution in assessing the data for this small subsample. Throughout this report, we provide totals for all GLOBE teachers, regardless of nationality, unless otherwise noted.

Table 2.2
Teacher Survey Response Rates

Population	*Sample Size*	*Number Responding*	*Response Rate (Percent)*	*Percent Responding on Web*
U.S. franchise trained	120	81	68	10
U.S. other	315	246	78	18
International	140	51	36	41
Total	575	378	66	20

Case Studies

Our research plan included site visits and the development of snapshot case studies for four sites. Given the evolution of the GLOBE program and the issues identified in earlier years' evaluations, we decided to select schools for case study that represented specific strengths in areas of concern to the program as a whole. We wanted representation of different implementation models, ranging from an after-school or lunch club to a formal course devoted entirely to GLOBE. Within these models, we sought examples of multidisciplinary teaching, use of Soil protocols, and implementation of GLOBE within an urban setting.[1] Responses to the 1997 teacher survey were used to identify candidate sites in each category, and each school's level of activity in reporting data during the 1997-98 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 teachers at the most active schools in each category were used to make final selections.

[1] We also sought an active data-reporting site run by franchise-trained teachers, but perhaps because franchise training had only recently gotten under way on a significant scale, we were unable to locate an active volunteer site in the fall of 1997.

Through this process, four sites were selected for study: Ft. Lowell Elementary School, Tucson, AZ; Randolph Magnet School, Chicago, IL; St. Peter's Catholic School, Waldorf, MD; and Talley Middle School, Wilmington, DE. Site visits were conducted between December 1997 and April 1998. Each visit was scheduled for a 3-day period and included interviews of GLOBE teachers, observations of GLOBE activities (including accompanying students to data collection sites), informal discussions with students, and, where appropriate, interviews with administrators who had been most involved in getting the program started within the school. In addition, we pilot tested an open-ended interview technique designed to elicit students' thinking about the environment to see whether we could use such an instrument in later data collections to evaluate GLOBE's impact on environmental awareness. Some of the findings of this preliminary work are described in Chapter 6.

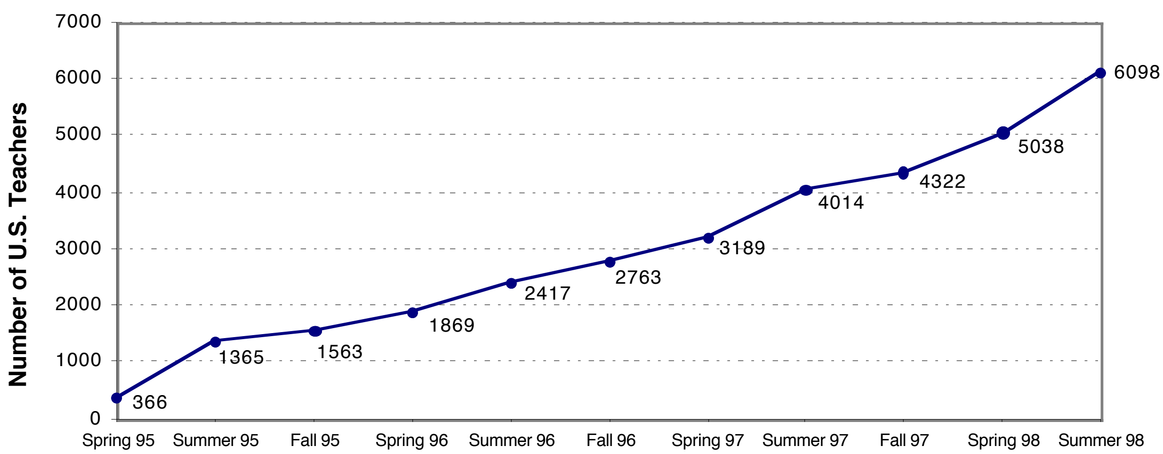
Chapter 3. Program Growth

In its third year, the GLOBE program has continued to engage hundreds of teachers and thousands of students. This chapter focuses on quantitative indices of program growth, including the number of teachers trained, training methods, number of schools reporting data, and the number of reports of each measurement type submitted each month. Wherever possible, we make comparisons across Years 1, 2, and 3. Chapter 4 discusses program implementation patterns, and Chapter 6 discusses influences on students and teachers.

The Number of Teachers Trained

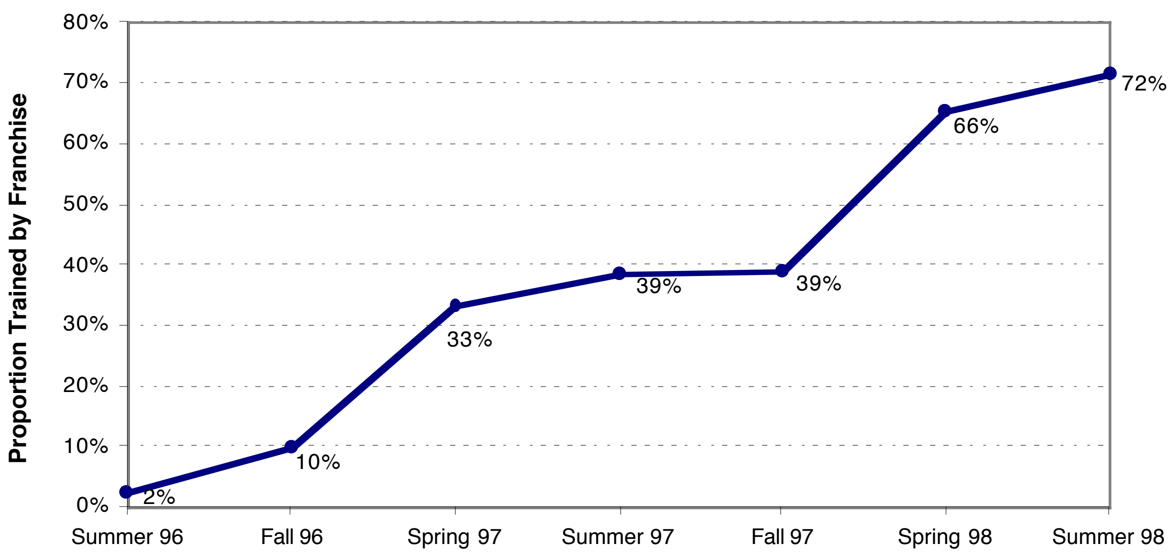
Since the inception of the program in 1995, GLOBE has emphasized the importance of teacher training. By the beginning of September 1998, more than 6,000 teachers had been trained in the United States (representing 4,510 schools), and more than 1,600 teachers outside the United States had received GLOBE training (representing 1,359 schools). Figure 3.1 shows the steady growth in the number of U.S. teachers trained since the program's inception.

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



One of the biggest program changes in 1997-98 was the increasing reliance on regional "franchises" as the strategy for training U.S. teachers. The number of teachers trained by franchises in the United States increased dramatically from September 1997, when it was 318, to September 1998, when it reached 1,854. During the summer of 1998, 72% of the teachers trained received their training through a GLOBE franchise. Figure 3.2 shows the rapid increase in the proportion of U.S. teachers trained by a franchise during successive quarters. Since the program's inception, 30% of all teachers trained in the United States have been trained by a GLOBE franchise (cumulative percentage as of September 1998).

Figure 3.2
Growth in Proportion of U.S. Teachers Trained by Franchises



Number of Reporting Schools

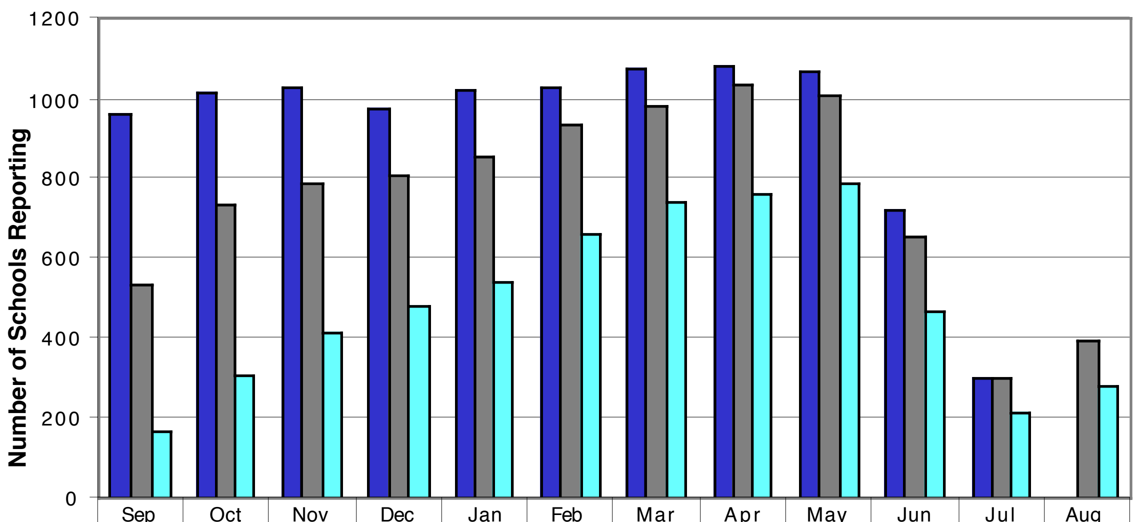
We examined the number and proportion of schools reporting GLOBE data and the average amount and number of types of data contributed by each school. These analyses are based on monthly data summaries prepared by NOAA's Forecast Systems Labs.[1]

As of August 1998, 42% of the U.S. schools that have had one or more teachers trained in GLOBE (1,896 out of 4,510) had reported data.

[1] Our thanks to Michael Turpin and Phil Pierce for their help in preparing these data.

Figure 3.3 shows that last year's upward trend in the number of schools reporting data continued to hold true in the 1997-98 school year. However, the month-to-month pattern changed from that in the 1996-97 school year. September's figures again show a significant increase over the previous year in the number of schools reporting (960 schools, compared with 529 in September 1996), but the numbers level out at between 1,000 and 1,100 schools each month rather than showing regular incremental monthly growth, as in the first two years of the program. These data are consistent with the interpretation that there is a core group of schools that start collecting data in September and report consistently throughout the Northern Hemisphere's typical school year. Alternatively, it may be that the number of new schools coming on-line after October just happens to be balanced by the number ceasing to report data. There continues to be a steep drop-off in reporting during the summer months, showing a reduction of the core group to about 300 schools.

Figure 3.3
Number of Schools Reporting Data in GLOBE Years 1-3



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
97-98	960	1014	1032	976	1026	1028	1078	1084	1065	720	301	N/A
96-97	529	735	793	806	857	936	983	1034	1011	652	304	391
95-96	170	308	415	485	543	660	736	763	792	468	210	283

Reporting Patterns for Different Data Types

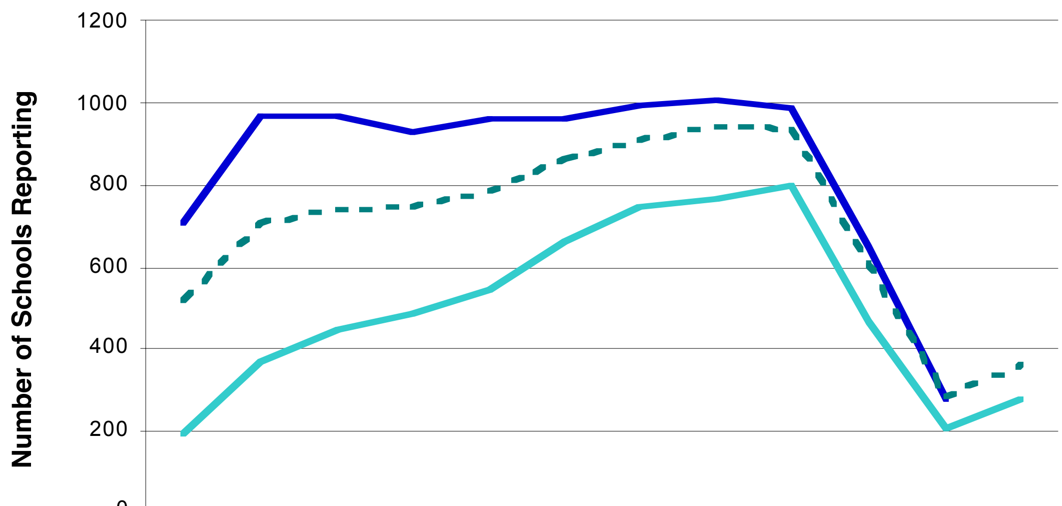
To examine the data reporting patterns for specific types of data, we charted the number of reports on a monthly basis separately for each measurement group, as shown in Figures 3.4 through 3.9.

More Frequent Data Types

The most commonly reported measurements, daily cloud observations, were reported by more schools earlier in the school year, hitting an early spike by October, and staying at nearly the same level throughout the school year (see Figure 3.4). The frequency of air temperature measurements (Figure 3.5) also started out higher in September than in previous years but, unlike cloud measurements, continued to follow the past pattern of increasing incrementally up through the Northern Hemisphere's spring.

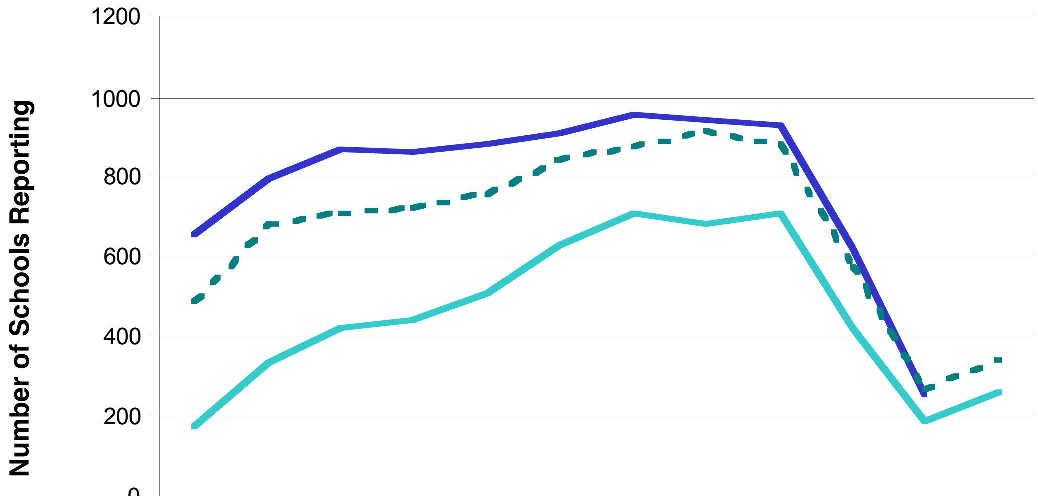
To get a sense of how many schools collect data every month throughout the school year, we computed the percentage of schools reporting data who did so for 9 or more months of the year. Of the 1,719 schools that reported data at any time during Year 3 (September 1997 - August 1998), the percentages reporting these atmospheric measurements for at least 9 months out of the year were 15% (Air Temperature), 18% (Cloud Observations), 12% (Rain), and 3% (Snow).

Figure 3.4
Number of Schools Reporting Cloud Observation Data, by Month and Year



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Cloud 97-98	709	965	966	930	962	961	1000	1006	988	651	273	N/A
Cloud 96-97	522	704	743	746	782	862	909	948	934	604	286	358
Cloud 95-96	194	369	449	488	548	658	750	770	799	468	205	274

Figure 3.5
Number of Schools Reporting Air Temperature Data, by Month and Year



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Air Temp 97-98	651	798	873	860	880	908	957	942	927	619	257	N/A
Air Temp 96-97	490	679	713	724	759	843	878	915	883	577	273	340
Air Temp 95-96	176	333	423	443	510	628	713	682	707	426	186	258

The numbers of schools reporting liquid and solid precipitation data (Figures 3.6 and 3.7) saw an increase overall and followed their previous patterns of incremental growth throughout the typical school year, with a decline in the winter vacation period. There is a tendency for more schools to report these data when there is rain or snow to collect; therefore, the number of schools reporting and the frequency of the reports are understandably lower than the air temperature and cloud observation measurement groups.

Less Frequent Data Types

Figure 3.8 shows the number of schools reporting Hydrology data in Years 1-3.[2] Fewer schools reported Hydrology data each month in 1997-98 than in 1996-97, but the major part of this decrease may be attributable to a change in the frequency of data collection for the Hydrology protocols. GLOBE I protocols required weekly measurements of Hydrology variables. When GLOBE II protocols were

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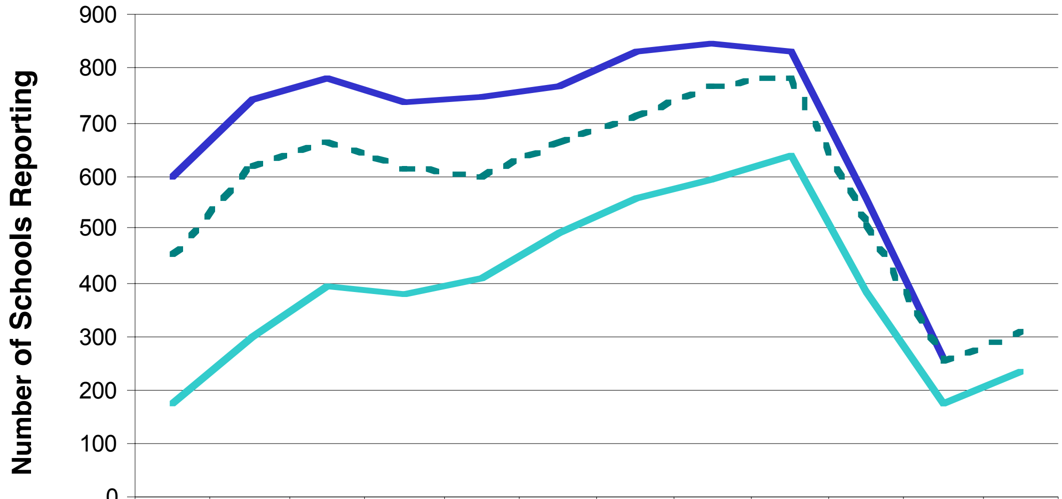
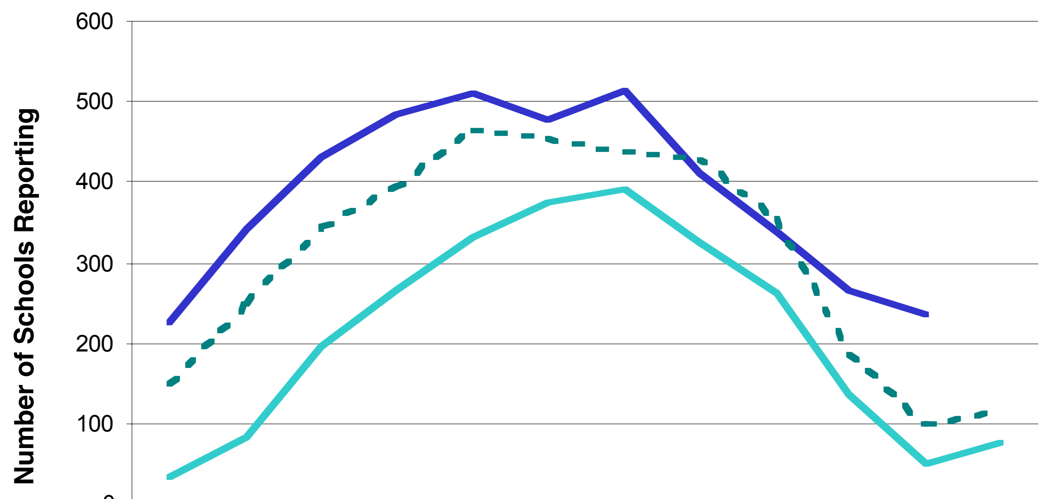
[2] NOAA's data summary lumps together the various Hydrology protocols (Water Temperature, pH, Dissolved Oxygen, Alkalinity, etc.), counting all those submitted at the same time as one report, regardless of the number of pieces of data submitted on the Hydrology report form.

Figure 3.6
Number of Schools Reporting Liquid Precipitation Data, by Month and Year



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Rain 97-98	601	741	782	737	747	765	833	849	833	561	260	N/A
Rain 96-97	455	619	663	616	599	663	716	768	785	509	257	307
Rain 95-96	175	300	395	379	410	492	562	597	639	388	174	236

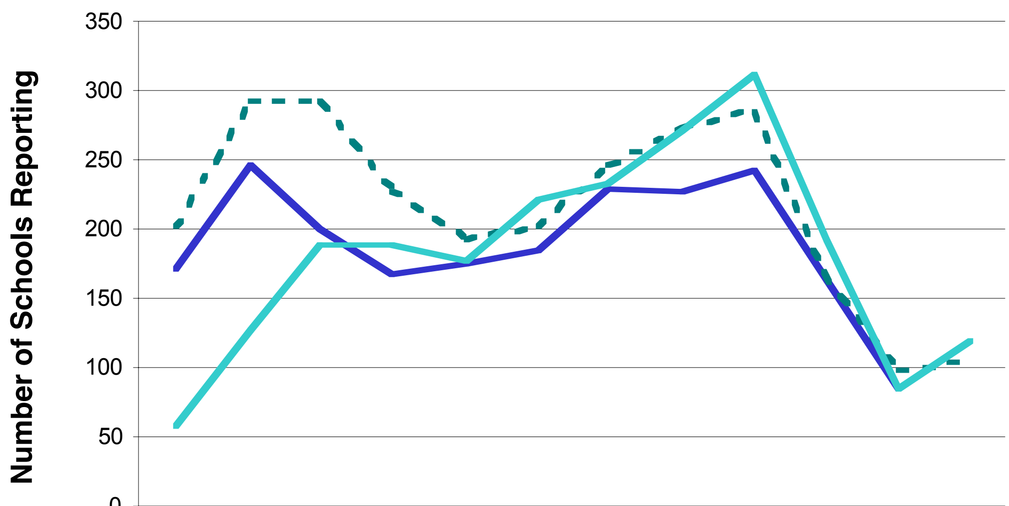
Figure 3.7
Number of Schools Reporting Solid Precipitation Data, by Month and Year



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Snow 97-98	229	344	433	485	510	479	515	415	340	267	237	N/A
Snow 96-97	149	251	346	396	466	455	437	431	357	189	100	114
Snow 95-96	34	85	197	268	334	376	392	326	263	140	53	79

introduced in June 1996, the frequency of data collection was decreased to monthly, with a weekly frequency as an option. The frequency of the measurements was changed back to weekly with the introduction of the revised Hydrology protocols in the 1997 Teacher's Guide Supplement (made available on the GLOBE Web site in August 1997). The emerging pattern for Hydrology from 1997-98 and 1996-97 shows that the number of schools reporting data increases dramatically from September to October, declines during the Northern Hemisphere winter months, and rises back to October's levels in the spring. Few schools (35 out of the 642 who reported Hydrology data in 1997-98), however, indicated in their reports at any time that their sites had iced over or had run dry with no free-running water available from which measurements could be taken.

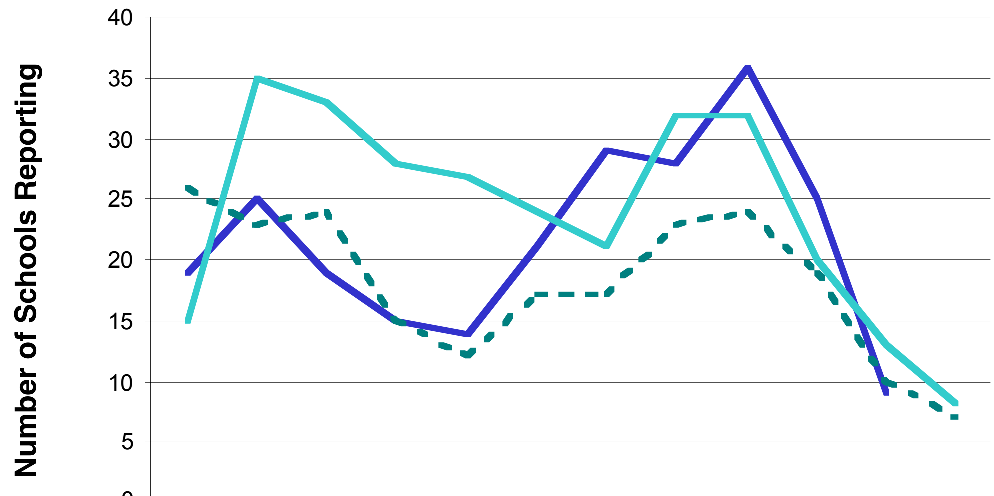
Figure 3.8
Number of Schools Reporting Hydrology Data, by Month and Year



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Hydrology 97-98	172	247	202	168	176	186	230	229	242	165	86	N/A
Hydrology 96-97	203	292	293	229	194	203	247	274	286	167	98	106
Hydrology 95-96	59	129	189	189	178	222	234	272	312	193	87	119

The GLOBE Soil Moisture protocol's data collection frequency (Figure 3.9) was also reduced from daily to monthly when GLOBE II protocols were introduced in June 1996. Unless a school already had the gypsum blocks installed for the original protocol, most schools started using the new gravimetric protocol, which called for submitting data only once per month. The pattern of the last 2 years remains consistent, with 20 to 25 schools submitting data each month in the fall, a decline in winter, and a resurgence of data reporting in the spring. The number of schools reporting Soil Moisture data in the spring was higher in 1997-98 than in the previous year, possibly because of the program's modification of the protocol in ways that made it easier to understand and implement with confidence.

Figure 3.9
Number of Schools Reporting Soil Moisture Data, by Month and Year



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Soil Moisture 97-98	19	25	19	15	14	21	29	28	36	25	9	N/A
Soil Moisture 96-97	26	23	24	15	12	17	17	23	24	19	10	7
Soil Moisture 95-96	15	35	33	28	27	24	21	32	32	20	13	8

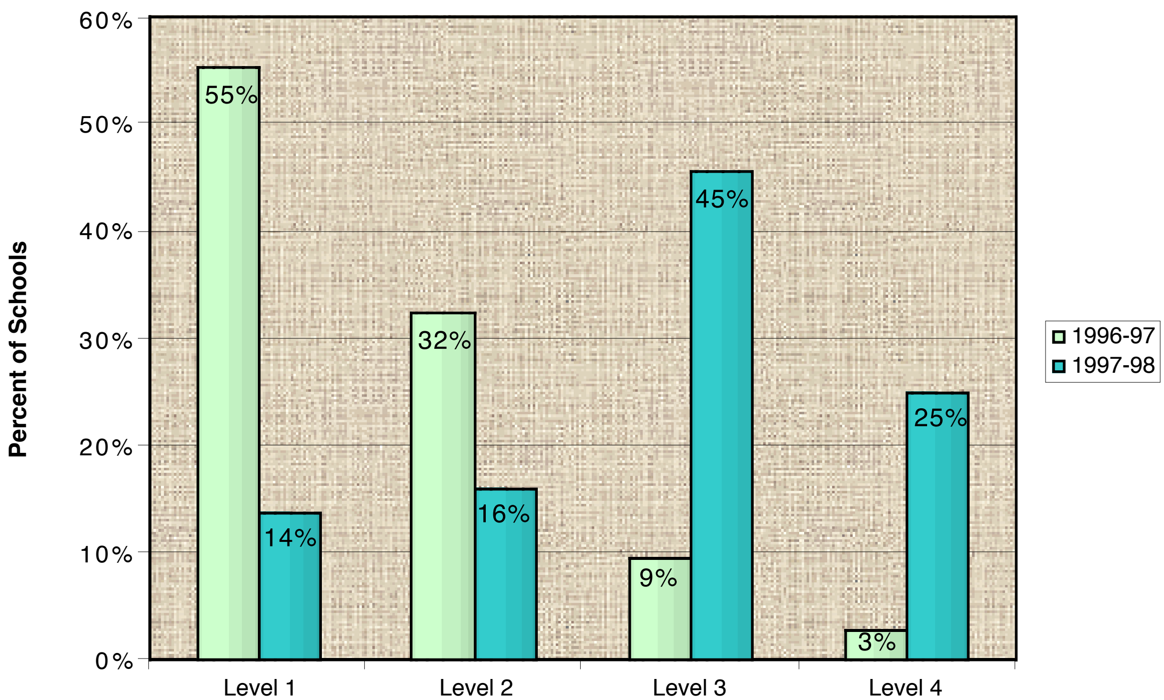
From the inception of the GLOBE II protocol data reporting in October 1996 through August 1998,[3] 91 schools made 118 reports of Land Cover Qualitative data. Just 27 schools reported Modified UNESCO Classification system (MUC) codes during the 1997-98 school year, down from 64 in 1996-97. Nevertheless, among schools that did report MUC codes in 1997-98, more specific code levels (higher numbers) were used than in the previous year (see Figure 3.10). This finding indicates that these schools are going deeper into the protocols—not stopping at selecting a Biology Land Cover site and assigning the most appropriate MUC Level 1 category, as did the majority of the 1996-97 reporters.

Quantitative Land Cover data reported for the same period show a different pattern, with more schools reporting data in 1997-98 (39) than in 1996-97 (22). The Land Cover Quantitative data most frequently reported were Genus, Species, Height, and Circumference of the dominant tree species. The level of reporting for these

[3] Some schools are continuing to report Land Cover/Biometry measurements under the GLOBE I protocols, and these schools are not included in the report counts discussed above.

measurement types remained stable over the last two school years, with the exception of the Green and Brown Biomass measurements, which increased slightly.

Figure 3.10
Distribution of MUC Levels Reported in 1996-97 and 1997-98



Note: Some types of land cover can be classified only to Level 2.

The Soil Temperature protocol calls for measurements to be taken weekly at depths of 5 cm and 10 cm. Schools started collecting these data in October 1997. Relatively few schools implemented this protocol in 1997-98, but some of these schools were extremely productive. By September 1998, 41 schools had submitted more than 6,500 measurements, with more than half of these observations coming from a school in Germany that records the temperatures daily at two different sites. Ten schools have been reporting Soil Temperature data on a regular basis (more than 70 data measurements over the last year).

Average Number of Data Types Reported per School

We looked also at the number of different types of data reported by the average school. The overall number of data types that schools report has remained relatively consistent, increasing just slightly from 3.7 to 4.0 types over the past 3 years. The number of types of data reported by U.S. schools has remained constant at approximately 3.5 data types per school each year. International schools have increased their averages from 4.2 to 5.1 types of data over the same period.

Effects of Multiple Teachers per School on Reporting Patterns

Over the past several years, GLOBE has encouraged schools to send multiple teachers to GLOBE training and to use a team approach to implementing the program. As the number of GLOBE schools that have had programs with multiple teachers for several years increases, we can start to look empirically at the extent to which such schools implement the program more broadly or sustain it for a longer time. For the group of U.S. GLOBE schools that had teachers trained as of September 1996, we examined (1) the number of teachers trained, (2) the likelihood that the school reported data during the next two school years, and (3) the relationship between them. Among the subset of 199 of these schools that had had more than one teacher trained, 26% reported data in the 1997-98 school year. This proportion is significantly higher than the 17% of the 2,002 U.S. schools with only one GLOBE teacher trained that were reporting data in 1997-98. Next year, we will be able to perform more detailed analyses as the number of schools with multiple teachers trained 2 years before increases.

Conclusion

The total number of teachers trained and the total number of schools reporting GLOBE data continue to grow. Nevertheless, relatively few schools are reporting data for investigations other than Atmosphere. The fact that they are not reporting data does not necessarily mean that schools are not benefiting from educational aspects of the GLOBE program. In Chapter 4, we examine the teacher survey data to estimate the proportion of GLOBE classrooms using content (i.e., protocols, learning activities, or information) from each of the investigations.

Chapter 4. Characteristics of Local GLOBE Programs

When asked whether they were involved with GLOBE during the 1997-98 school year, 68% of our survey respondents said "yes." Sixty-five percent of our respondents said that they had implemented the program with students. Other forms of involvement cited by respondents were leadership roles, such as coordinating GLOBE implementation at their school or district, training others, or receiving training themselves. Thirty-two percent of survey respondents said that they had not been involved with the program during 1997-98.

In the remainder of this chapter, we draw on the survey responses of the 239 teachers who did implement the program with students in 1997-98 to try to understand the characteristics of local GLOBE programs and the factors that underlie teacher decisions concerning which parts of the program to implement.

School Implementation Patterns

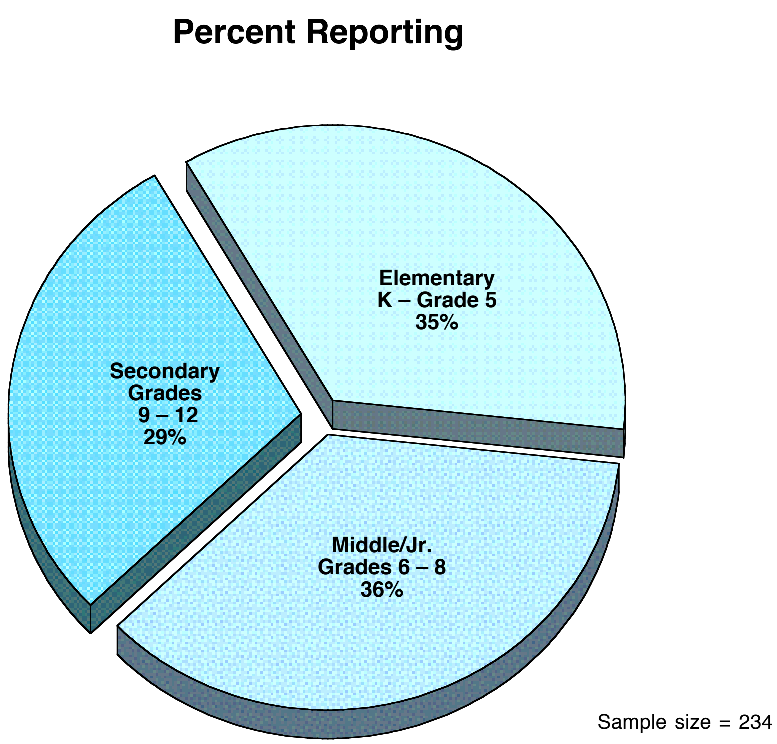
The teachers in our survey sample who implemented GLOBE with students during the 1997-98 school year provided a portrait of the range of settings within which GLOBE was implemented. GLOBE can be used at any grade level K-12, and Figure 4.1 provides a look at the levels at which the program was characteristically implemented. Roughly speaking, one-third of GLOBE teachers implemented the program at the elementary level, one-third at the middle school or junior high level, and one-third at the high school level (more precisely, 35%, 36%, and 29%, respectively).[1] International GLOBE teachers were less likely than U.S. teachers to be working within elementary settings and more likely to be working at the higher grade levels.

GLOBE was most often conducted as a part of a regular class, but pull-out programs, clubs, and lunch activities were not uncommon, as shown in Table 4.1. When GLOBE was offered within elementary school classes, it was usually a regular general elementary classroom rather than a special class taught by a science teacher. This fact suggests that most teachers implementing GLOBE at the elementary level will have a limited science background on which to draw, potentially making portions of the GLOBE training quite challenging for them. At the middle and secondary school levels, pull-out programs and

[1] For this analysis, teachers reporting working with students in grades 6-8 are counted as working at the middle school/junior high level regardless of their school's name or designation.

clubs or lunch activities were used more commonly internationally than in the United States. At these levels, GLOBE was most commonly taught in Earth/space science, environmental science, and general science classes (20%, 16%, and 14%, respectively, of the middle and secondary school classes within which GLOBE was conducted). GLOBE was sometimes but rarely taught within biology/life science classes (4% of middle and secondary classes), chemistry (3%), physical science (3%), mathematics (3%), physics (1%), and social studies (1%). GLOBE was often taught in science classes with other titles (24% of the middle and secondary classes within which GLOBE was taught). One school, for example, established a new course called Environmental Science and Technology.

Figure 4.1
Educational Levels at Which GLOBE Is Implemented



Just over half of the U.S. teachers in the survey sample who implemented GLOBE reported being the only teacher implementing the program in their schools. This number compares with 72% in the 1996 survey, reflecting the trend noted in Year 2 toward having more school GLOBE programs conducted by multiple GLOBE teachers. Around 30% of teachers said they were one of two GLOBE teachers at their school, 9% one of three, and 6% one of a larger number of teachers, as shown in Figure 4.2.

Table 4.1
Teacher Reports of Setting within Which GLOBE Is Implemented
(Percent Reporting)

Setting	U.S.	International	Overall
Comprehensive elementary class	32	7	27
Elementary science class	7	7	7
Elementary lunch or club	3	7	4
Other elementary	2	2	2
Regular middle or high school class	51	24	46
Middle or high school pull-out program	2	37	8
Middle or high school lunch or club	3	15	5
Other middle or high school	1	0	<1
Sample sizes:	n = 186	n = 41	n = 227

Teacher Time Devoted to GLOBE

An issue identified in previous evaluation reports is the amount of time required to set up the equipment and the technology for implementing GLOBE, as well as the difficulty of fitting GLOBE within the scheduling and curriculum constraints of the typical classroom. In the 1998 survey, teachers who had implemented GLOBE during the school year were asked to estimate the amount of time they spent planning and preparing for GLOBE activities in a typical week. Teachers in our survey sample who had implemented GLOBE said they spent an average of 2.2 hours a week on these preparations. It should be noted that this estimate is additional time required for GLOBE preparation on an ongoing basis; it does not reflect the time required for initially acquiring and setting up the equipment and technology for implementing GLOBE. These same teachers estimated that they spent an average of 2.4 hours a week on GLOBE activities with their single most active GLOBE class or club.

Figure 4.2
Number of GLOBE U.S. Teachers per School, by Year

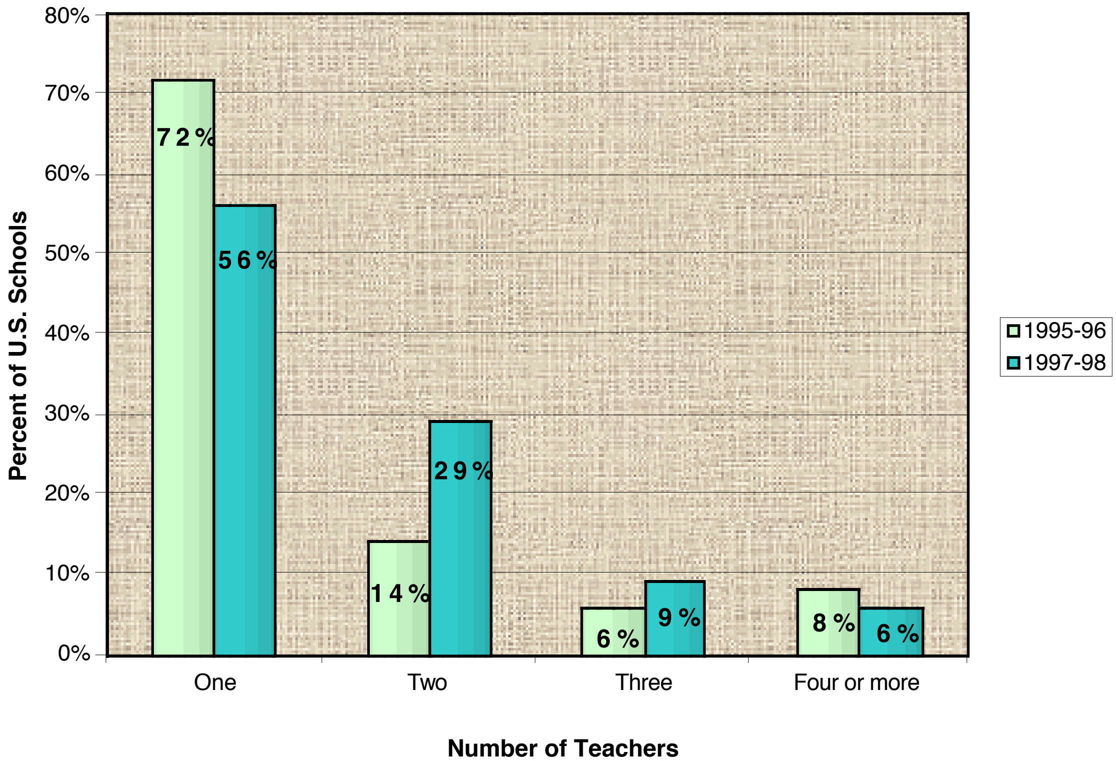


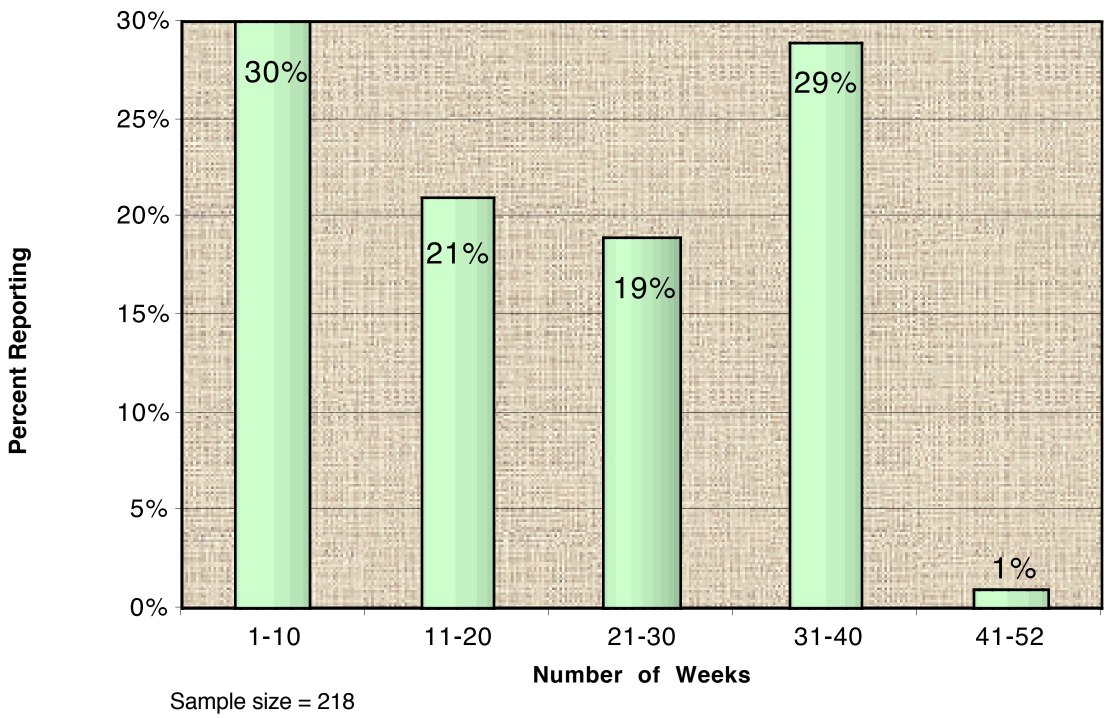
Figure 4.3 shows the distribution of teacher responses to the survey question about the number of weeks of the year during which they implement GLOBE with their students. Although GLOBE was originally intended as a program of continuous year-long data collection, it is quite clear that teachers often plan for shorter terms of involvement for their students. The mean number of weeks a single class spent implementing GLOBE activities is 22.

Implementation of Specific Components of GLOBE

Teachers were asked to indicate which components of GLOBE they had implemented with students in school year 1997-98 and how they organized those activities. Figure 4.4 shows the extent to which teachers who reported implementing GLOBE had their students engage in each of five major components.

Virtually all of the teachers who said on the survey that they had implemented GLOBE with students reported having their students collect data. This finding suggests that teachers view data collection as the essence of GLOBE implementation. Not all of the teachers whose students collected data had the students report them to the GLOBE data server, however; 24% of GLOBE teachers whose students collected data said that their students did not put data into the computer. (Given the question wording, it is likely that some of these teachers input the data themselves.)

Figure 4.3
Number of Weeks in Which GLOBE Is Implemented during the School Year



A major indicator that GLOBE classrooms are moving toward more well-rounded implementation of the program is the percentage of teachers implementing other GLOBE components: 72% of teachers did GLOBE learning activities with their classes, and 62% analyzed, discussed, or interpreted GLOBE data. A smaller proportion—44%—explored information on the GLOBE Web site.

Table 4.2 displays the teacher reports for how they organized their students for engaging in these components of GLOBE. Teachers typically had a single small group of students take GLOBE measurements, enter GLOBE data on the computer, and explore information on the GLOBE Web site. (The latter two activities are likely to be constrained by the nature and number of computers available to the teacher.)

Discussions of GLOBE data and GLOBE learning activities, on the other hand, typically involve the whole class. The increased emphasis on these components of GLOBE, then, is likely to result in more involvement on the part of a broader group of students.

Figure 4.4
Level of Student Engagement in GLOBE Component Areas

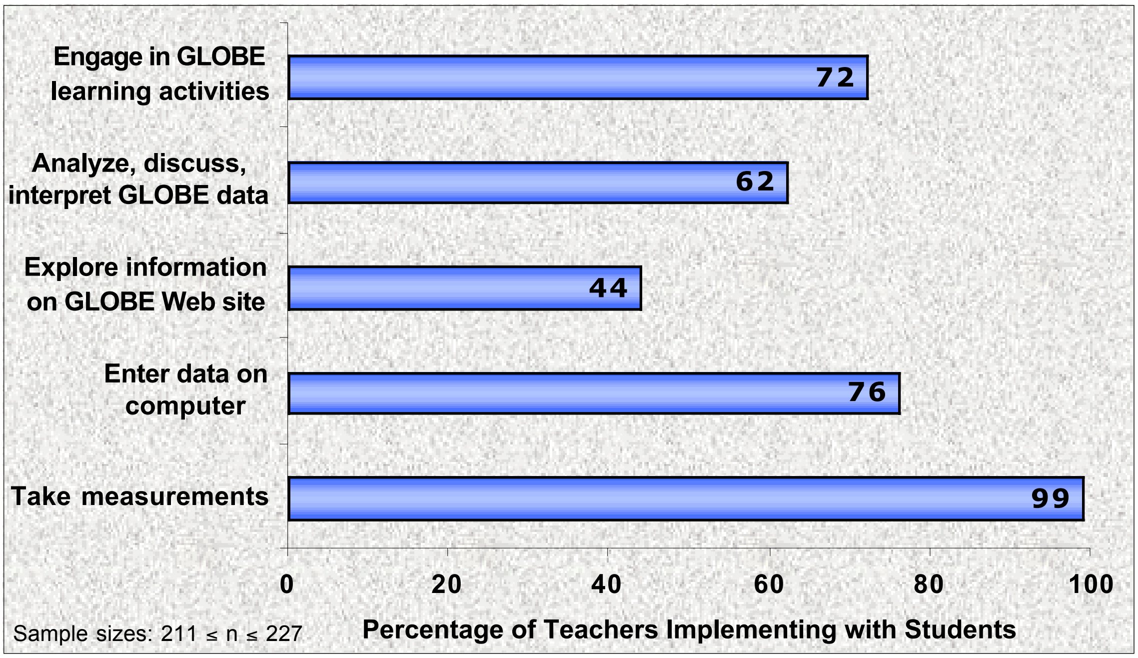


Table 4.2
Teacher Reports of Student Participation in GLOBE Activities in a Typical Week (Percent Reporting)

GLOBE Activity	Single Student	Small Group	Multiple Small Groups	Whole Class
Take GLOBE measurements	5	71	16	8
Enter GLOBE data on computer	28	64	4	4
Explore information on GLOBE Web site	21	52	12	15
Analyze, discuss, interpret GLOBE data	2	23	9	66
Engage in GLOBE learning activities	1	15	14	70

Sample sizes: 94 ≤ n ≤ 222

Implementation of GLOBE Data Collection Protocols

The number of data collection protocols and learning activities in GLOBE has increased markedly since the first Teacher's Guide was issued in 1995. The 1997 Guide, which was current at the time the spring 1998 survey was constructed, contains 29 different environmental science measurement protocols and 41 learning activities. Both new and veteran GLOBE teachers can be overwhelmed by the amount and complexity of material in GLOBE.

In the Year 2 evaluation report, we identified the low implementation rates for the then-new GLOBE II protocols as an issue of concern. In the Year 3 survey, we again queried teachers concerning the protocols they had implemented or planned to implement.

Teachers implementing GLOBE with students were asked to indicate which specific protocols they had implemented and their plans with regard to those they had not yet implemented. Tables 4.3 through 4.7 show the teacher responses for the five investigation areas. Because implementation rates for some protocols and activities vary markedly by level of school (and some are not intended for elementary implementation), elementary school implementation rates are shown separately from those of middle and secondary schools.

In general, the implementation rates were quite high for most of the Atmosphere protocols, with the exceptions of Solid Precipitation (which schools tend to implement only if there is something to measure) and a new protocol, Precipitation pH. Cloud Type and Cloud Cover, two protocols that require no equipment, were by far the most commonly implemented GLOBE protocols, being used by 88% and 87% of GLOBE teachers, respectively.

Hydrology protocols were implemented at lower rates, as shown in Table 4.4. The most commonly implemented Hydrology protocols were Water pH and Water Temperature, both used in 33% of GLOBE classrooms. Some of the protocols (Dissolved Oxygen, Alkalinity, Salinity Titration, and Nitrate) are not expected to be performed at the elementary level, but even within middle and secondary schools, implementation rates for these protocols ranged between just 2% and 24%. A sizable proportion of teachers at these grade levels reported having definite plans to introduce these protocols, however. All of the Hydrology protocols were performed by significantly higher proportions of middle and secondary than elementary schools.

Table 4.3
Implementation Rates for GLOBE Atmosphere Protocols, by School Level
(Percent Reporting)

Protocol	Elementary Teachers: Have Implemented	Elementary Teachers: Definitely Will Implement	Middle/Secondary Teachers: Have Implemented	Middle/Secondary Teachers: Definitely Will Implement
Min/Max/Current Temperature	78	20	75	19
Rainfall	77	20	72	22
Precipitation pH	37	31	37	37
Solid Precipitation	50	23	40	26
Cloud Cover	91	7	84	12
Cloud Type	93	5	86	10
Sample sizes:	$74 \le n \le 81$		$136 \le n \le 152$	

Table 4.4
Implementation Rates for GLOBE Hydrology Protocols, by School Level
(Percent Reporting)

Protocol	Elementary Teachers: Have Implemented	Elementary Teachers: Definitely Will Implement	Middle/Secondary Teachers: Have Implemented	Middle/Secondary Teachers: Definitely Will Implement
Water Transparency	4	23	18	39
Water Temperature	24	31	36	38
Dissolved Oxygen*	6	31	24	40
Water pH	19	30	39	36
Electrical Conductivity	2	15	18	39
Salinity**	3	14	6	32
Salinity Titration*	2	9	4	25
Alkalinity*	8	24	22	38
Nitrate*	0	15	14	33
Sample sizes:	$66 \le n \le 70$		$139 \le n \le 149$	

* Not recommended for implementation at beginner (elementary) level.

** Salinity protocol applies to saltwater sites. Freshwater sites use the Electrical Conductivity protocol.

Implementation rates for Land Cover/Biology protocols were even lower, ranging from 3% to 15% overall. Middle and secondary school teachers were more likely than elementary teachers to report that they definitely *planned* to implement these protocols (37% to 47%, compared with 21% to 34%).

Table 4.5
Implementation Rates for GLOBE Land Cover/Biology Protocols, by School Level
(Percent Reporting)

Protocol	*Elementary Teachers*		*Middle/Secondary Teachers*	
	Have Implemented	*Definitely Will Implement*	*Have Implemented*	*Definitely Will Implement*
Qualitative Land Cover	15	29	15	46
Quantitative Land Cover	9	34	13	47
Land Cover Mapping	5	26	8	45
Accuracy Assessment	4	21	2	37

Sample sizes: 73 ≤ n ≤ 77 140 ≤ n ≤ 151

Implementation rates for the Soil protocols were low also. None of the elementary-level teachers in the survey sample had implemented the Soil Characterization Laboratory Analysis, Gravimetric Soil Moisture, or Infiltration protocol. Among middle and secondary teachers, reported implementation rates for these protocols ranged from 4% to 8%. The most commonly implemented Soil protocol was Field Soil Characterization, which was implemented by 15% of middle and secondary school teachers in the survey sample and 3% of elementary teachers. The Gypsum Block Soil Moisture protocol, which is an alternative to the Gravimetric protocol and not recommended at the elementary level, was implemented by 3% of the middle and elementary teachers.

The basic GPS Measurement protocol was implemented by a fairly high proportion (55%) of teachers. The Offset GPS protocol, which is not recommended at the elementary level, was implemented by 16% of middle and secondary teachers and 11% of elementary teachers.

Table 4.6
Implementation Rates for GLOBE Soil Protocols, by School Level
(Percent Reporting)

Protocol	Elementary Teachers		Middle/Secondary Teachers	
	Have Implemented	Definitely Will Implement	Have Implemented	Definitely Will Implement
Soil Characterization Field Measurements	3	37	15	35
Soil Characterization Lab Analysis	0	32	8	37
Gravimetric Soil Moisture	0	20	4	31
Gypsum Block Soil Moisture*	0	13	3	21
Soil Temperature	1	34	6	42
Infiltration	0	19	4	28

Sample sizes: 71 ≤ n ≤ 73 139 ≤ n ≤ 145

* Designated as optional protocol, not recommended for beginner (elementary) level.

Table 4.7
Implementation Rates for GLOBE GPS Protocols, by School Level
(Percent Reporting)

Protocol	Elementary Teachers		Middle/Secondary Teachers	
	Have Implemented	Definitely Will Implement	Have Implemented	Definitely Will Implement
GPS	55	23	55	30
Offset GPS*	11	29	16	34

Sample sizes: 62 ≤ n ≤ 77 117 ≤ n ≤ 142

* Not recommended for implementation at beginner (elementary) level.

Implementation of GLOBE Learning Activities

Teachers implementing GLOBE with students were asked also about their implementation of specific learning activities. Tables 4.8 through 4.13 show the teacher responses concerning learning activities. It should be remembered that learning activities are regarded as important but optional within the GLOBE program and are intended to be resources for teachers, who may pick and choose those they regard as most appropriate for their students. In general, implementation rates were higher for learning activities within investigations where protocol implementation rates were higher (and vice versa). The single most frequently implemented learning activity was Observe/Describe/Identify Clouds, which was implemented by 90% of elementary and 83% of middle and secondary teachers. At the other extreme, eight learning activities were implemented by 5% or fewer of the teachers in our sample.

Comparing 1997 and 1998 survey respondents, reported learning activity implementation rates were very similar across the two years in the Hydrology, Land Cover/ Biology, Soil, and GPS investigations. The 1998 respondents had a higher average implementation rate for Atmosphere learning activities, and the 1997 respondents had a higher average implementation rate for Seasons learning activities (many of which emphasize analysis of data).

Table 4.8
Implementation Rates for GLOBE Atmosphere Learning Activities, by School Level
(Percent Reporting)

Learning Activity	Elementary Teachers		Middle/Secondary Teachers	
	Have Implemented	Definitely Will Implement	Have Implemented	Definitely Will Implement
Observe/Describe/Identify Clouds	90	8	83	7
Estimate Cloud Cover	79	14	73	12
Study Instrument Shelter	68	16	53	20
Build Thermometer	24	27	22	20
Land/Water/Air	29	32	25	20
Cloud Watch	61	22	47	20

Sample sizes: 73 ≤ n ≤ 79 (Elementary); 137 ≤ n ≤ 149 (Middle/Secondary)

Table 4.9
Implementation Rates for GLOBE Hydrology Learning Activities, by School Level
(Percent Reporting)

Learning Activity	Elementary Teachers		Middle/Secondary Teachers	
	Have Implemented	Definitely Will Implement	Have Implemented	Definitely Will Implement
Water Walk	11	24	14	28
Model Watershed	7	28	8	22
Practice Protocols	21	24	28	30
pH Game	11	27	11	27
What Can Live Here?	9	28	9	29
Further Investigation	3	28	4	26
Water Detectives	7	26	7	30
Water Water Everywhere	13	27	9	25

Sample sizes: 68 ≤ n ≤ 70 137 ≤ n ≤ 142

Table 4.10
Implementation Rates for GLOBE Land Cover/Biology Learning Activities, by School Level
(Percent Reporting)

Learning Activity	Elementary Teachers		Middle/Secondary Teachers	
	Have Implemented	Definitely Will Implement	Have Implemented	Definitely Will Implement
Odyssey of the Eyes	7	19	8	22
Some Like It Hot	3	22	7	21
Discovery Area	6	19	3	25
Site Seeing	10	19	5	26
Seasonal Changes	11	20	4	31
Bird Classification	7	28	9	27
What's the Difference?	3	19	5	22
Leaf Classification	17	25	13	32

Sample sizes: 64 ≤ n ≤ 72 123 ≤ n ≤ 135

Table 4.11
Implementation Rates for GLOBE Soil Learning Activities, by School Level (Percent Reporting)

Learning Activity	*Elementary Teachers*		*Middle/Secondary Teachers*	
	Have Implemented	*Definitely Will Implement*	*Have Implemented*	*Definitely Will Implement*
Soil and My Backyard	11	25	9	26
Field View of Soil	4	30	7	24
Data Game	2	25	4	21
How Much Water Soil Holds	4	29	10	27
Soil—The Great Decomposer	7	27	9	25
Just Passing Through	3	27	4	23
Particle Size Distribution	1	29	3	24

Sample sizes: 68 ≤ n ≤ 71 132 ≤ n ≤ 137

Table 4.12
Implementation Rates for GLOBE GPS Learning Activities, by School Level (Percent Reporting)

Learning Activity	*Elementary Teachers*		*Middle/Secondary Teachers*	
	Have Implemented	*Definitely Will Implement*	*Have Implemented*	*Definitely Will Implement*
Relative/Absolute Direction	20	18	17	23
Working with Angles	13	21	9	26
Offset GPS Measurements	9	20	9	22
What Is the Right Answer?	6	20	5	18
Celestial Navigation	1	24	2	20

Sample sizes: 70 ≤ n ≤ 72 133 ≤ n ≤ 138

Table 4.13
Implementation Rates for GLOBE Seasons Learning Activities, by School Level
(Percent Reporting)

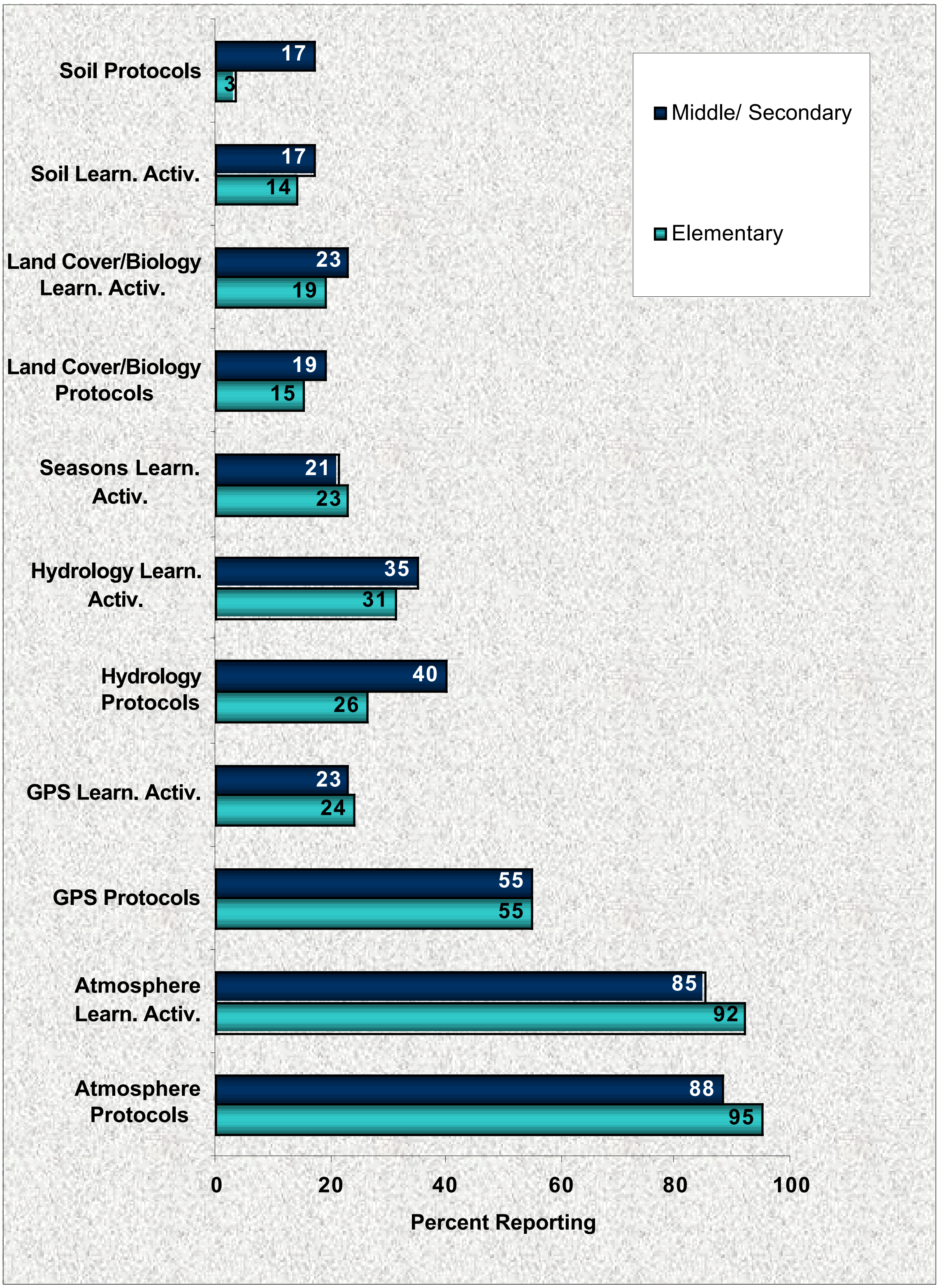
Learning Activity	Elementary Teachers		Middle/Secondary Teachers	
	Have Implemented	Definitely Will Implement	Have Implemented	Definitely Will Implement
Observing Seasonal Changes	15	35	13	30
Ask Questions	18	29	9	26
What Should Investigate	11	29	5	30
Graphs Explore Temperature Cycle	15	37	14	34
Select Other GLOBE School	4	23	7	22
Prepare Report on Investigations	6	23	7	25
Factors Affecting Seasonal Patterns	7	35	8	31
Sample sizes:	71 ≤ n ≤ 74		132 ≤ n ≤ 138	

Implementation Summary

The information shown in Tables 4.3 through 4.13—the implementation rates for individual GLOBE protocols and learning activities—is helpful in assessing the "return" on the investment in developing these pieces of GLOBE and training teachers to use them. From the standpoint of understanding how GLOBE gets implemented, it is useful also to know what proportion of GLOBE teachers implement at least one protocol (or learning activity) within each investigation area. Figure 4.5 provides these data. For each investigation area, it shows the proportion of teachers in the survey sample who reported implementing one or more protocols and the proportion who reported implementing one or more learning activities. Because of the difference in implementation patterns, elementary school teachers' responses are again shown separately from those of middle and secondary school teachers.

The variation in implementation rates across investigations shown in Figure 4.5 is dramatic. Ninety-five percent of elementary teachers and 88% of teachers at the middle

Figure 4.5
Proportion of Teachers Implementing GLOBE Investigations, by School Level



and secondary levels implemented at least one of the Atmosphere protocols. One or more GPS protocols were implemented by 55% of teachers. One or more Hydrology protocols were implemented by 26% of elementary and 40% of middle and secondary teachers. Fewer than 20% of teachers of either school level implemented one or more protocols in either Land Cover/Biology or Soil.

Because of the late release of the GLOBE II Teacher's Guide during the 1996-97 school year, there was speculation that the low implementation rates for protocols and learning activities found in the spring 1997 survey (see Year 2 evaluation report) reflected lack of time to absorb all the new material in the guide, especially on the part of teachers who had been trained with the GLOBE I materials. In the 1997 survey of teachers whose schools were active providers of GLOBE data, implementation rates for learning activities within each of the investigation areas lagged those for protocols. In 1998, we surveyed a representative sample of trained teachers rather than a sample drawn from active data providers, as in 1997. Not surprisingly, teachers in the 1998 survey of a representative sample of the teachers trained by GLOBE reported lower implementation rates for *protocols* than was reported the prior year by teachers selected on the basis of their above-average involvement in data reporting. In contrast, the 1998 survey respondents were overall just as likely as the active data providers responding to the 1997 survey to have conducted learning activities with their classes. Thus, the gap between implementation rates for protocols and learning activities was greatly reduced overall or, in some cases, closed entirely. Elementary teachers responding to the 1998 survey were more likely to report doing learning activities than protocols in both the Hydrology and Soil investigations.

Bases for Selecting Protocols and Learning Activities

Because low implementation rates for many of the GLOBE II protocols and learning activities were identified as an important issue in the Year 2 evaluation report, the 1998 survey included open-ended items asking teachers to explain the three chief criteria they used in deciding which protocols and which learning activities to use with their students. Table 4.14 contains the results of our analysis of the teacher responses. Overall, the teachers' responses suggest that they are very pragmatic in selecting activities for their classrooms. Feeling the limits on instructional time and the breadth of the charge assigned to them, they evaluate potential protocols and learning activities in terms of the expected benefits relative to the amount of time and effort required. As the table shows,

Table 4.14
Teacher Reports of Factors Determining Their Choice of Protocols and Learning Activities for Implementation
(Percent Reporting)

Factor	Protocols	Learning Activities
Ease of Implementation	63	49
Minimal time requirement	21	26
Availability of equipment/materials	17	12
Convenience of location/lack of transportation requirement	12	4
Ease of protocol procedures	7	2
Low cost	3	1
Ease of class/group management for this activity	3	1
Availability of support from other school staff	2	2
Weather/other geographic constraints	1	2
Curriculum fit	13	18
Match to students' level/interests	13	17
Familiarity/clarity of procedures	7	6
Quality of content	3	7
Conceptual support for protocols	NA	1
Other	1	2

Total responses: n = 597 n = 470
NA = Not applicable.

63% of the reasons cited for choosing protocols and 49% of those cited for choosing learning activities can be classified as some variant of the dimension "ease of implementation." This large category breaks down into subtypes based on the smaller amount of time required for some protocols/activities, the minimal requirement for equipment or materials, freedom from site/transportation requirements, ease of execution, low cost of instruments or supplies, ease of classroom management, availability of appropriate support for the protocol/activity, and lack of weather or geographic constraints.

The second and third major selection criteria involved curriculum fit (13% of reasons for choosing protocols and 18% for learning activities) and the match to the level or interests of their students (13% for protocols and 17% for activities). Familiarity or clarity of the protocol/activity was the focus of 7% of the reasons given for choosing protocols and 6% of those given for learning activities. Quality of the content (without explanation as to the dimensions on which it exhibited quality) was the criterion in 3% of the reasons given for choosing protocols and 7% of those given for learning activities. Exhibit 4.1 contains examples of some of the more fully stated reasons survey respondents gave for choosing the protocols and activities they did.

Effect of Time of Training on Implementation Rates

Analyses of data reporting patterns during the first 2 years of the program have shown that there is often a significant lag between the time a teacher receives GLOBE training and the time the teacher actually implements the program with students to the point of submitting data. Comments provided by our survey respondents illustrate some of the factors that may produce such delays:

> *I believe that it takes at least one year to work through the program to figure out how to implement the program. The training was done in August just before the school year started and all the materials were not in place at that time. This next year we know more about how to implement the program from the beginning and have some STUDENTS who can help teach the protocols.*

> *As a beginner in GLOBE, there is so much to learn before I can incorporate it into a class. I am taking a section at a time (atmosphere) and trying to become comfortable with that, and then moving on to other sections (GPS).*

Teachers in our survey sample were trained between June 1996 and December 1997. Some of them were therefore quite new to GLOBE and may have started with a small set of protocols and activities, expecting to add more as they become more familiar and comfortable with GLOBE. Certainly, the high proportions of teachers reporting that they "definitely plan to implement" many of the protocols with low implementation rates suggest this intention.

Exhibit 4.1
Examples of Teachers' Stated Criteria for Choosing Protocols and Learning Activities

Minimal time requirements

Time to carry out the activities.

Shortage of planning time.

Equipment/materials requirements

I had a chart for cloud cover so it was easy to start with cloud cover while I was waiting for the rest of the materials.

Absent equipment and time needed to scrounge it.

Location/transportation requirements

Need an area to collect data. We have one for weather.

Lack of funds to expand study sites to the river. No field trip money.

Match to students' interests/level

The ones I will not implement are too complicated for students at my level to conduct without my assistance.

Students' lack of abilities to comprehend harder materials and to do protocols that require the use of chemicals.

Curriculum fit

I won't implement protocols that I can't relate to my curriculum in some way.

The material covered. I want to have the information fit into what we are currently studying.

Those that fit with the [state] Essential Goals and Objectives we have chosen for our 7th and 8th grades [rather] than others.

Familiarity/clarity

We need more training in the areas that have not yet been implemented.

Quality of content

If I found another lesson with the same objective that I feel works better.

As an attempt to get at the effect of time since training on implementation rates, we divided the teachers who had implemented GLOBE with students into three groups, depending on when they received their GLOBE training. The first group consisted of those trained between June 1996 and December 1996, teachers who had a minimum of 9 months between their training and school year 1997-98. The second group was trained between January and May 1997 and the third group between June 1997 and December 1997. These groups varied significantly in their implementation rates for only one protocol (Solid Precipitation) and two learning activities (Building Thermometer and Graphs to Explore Temperature Cycles). In two of the three cases, implementation rates were higher for teachers trained earlier. Hence, at least within the limited range of time included in our sample, time since training had only a very modest influence on implementation patterns.

Use of GLOBE Web Site Features

Teachers implementing GLOBE with students were asked also about their use of technology features available through the GLOBE Web site. Table 4.15 shows the frequency with which classrooms of teachers implementing GLOBE with students used various technology resources available within GLOBE. These usage rates are lower than those found in the Year 2 survey of teachers whose classes actively submitted multiple types of GLOBE data. For example, 18% of the active data-providing GLOBE teachers surveyed in 1997 reported having students use visualizations of student data once a week or more, compared with 11% of the teachers responding to the 1998 survey.

Table 4.15
Frequency of Use of GLOBE Web Site Features
(Percent Reporting)

Feature	*Once a Week or More*	*1-3 Times a Month*	*<1 Time a Month*	*Once*	*Not at All*
Data entry	44	17	8	6	26
Visualizations of student data	11	19	25	8	38
Visualizations of reference data	6	15	23	11	45
GLOBEMail	10	12	19	12	47
GLOBE Student Data Archive	6	19	22	9	44
Scientists' Corner	2	6	20	13	59
Frequently Asked Questions	3	3	13	17	64
Web chat	2	1	7	12	78

Sample sizes: $215 \le n \le 227$

The lower usage rates in the 1998 sample of GLOBE teachers implementing the program can be explained in part by the fact that they had less Internet and computer access than the active GLOBE teachers surveyed in 1997. Twenty-two percent of 1998 respondents cited lack of adequate computers as a major barrier, and 36% cited lack of Internet access, compared with rates of 15% and 11% for these barriers in the 1997 survey of active GLOBE teachers.

Conclusion

In viewing these teacher reports on the parts of GLOBE they were implementing with their students, it should be remembered that the 1998 survey respondents are the implementing teachers from a random sample of GLOBE trainees. Unlike the 1997 survey respondents, they were not selected for inclusion in the survey on the basis of active participation in reporting GLOBE data. Even so, virtually all of these teachers were having their students take measurements, and large majorities were using GLOBE learning activities (72%) and having their students analyze, discuss, and interpret GLOBE data (62%). These findings suggest that major progress has been made since the first year of the program, when the collecting of the data often appeared to overshadow analytic activities. With respect to individual protocols and learning activities, it should be remembered that the GLOBE program seeks to promote a well-rounded implementation at each site, with the expectation that different teachers will implement different components of the total program. With a multi-teacher model, it is not necessary that the majority of teachers implement most or all of the protocols. From the empirical data, it seems clear that teachers will pick and choose those materials they feel are both appropriate for their students and reasonable in terms of the effort required. Much of the available material gets used by only a small percentage of teachers. The GLOBE program must determine the extent to which it wants to put resources into serving small (but potentially important) "niches" within science education as opposed to concentrating on topics that are covered more frequently and more thoroughly within K-12 programs.

Chapter 5. Implementation Challenges and Strategies

Previous evaluation reports have documented the many challenges that GLOBE poses both for teachers trying to start up a new program and for those implementing GLOBE on an ongoing basis. In this chapter, we examine the challenges GLOBE poses first from the perspective of teachers who received GLOBE training but had not implemented the program with their students by the spring of 1998 and then from the perspective of teachers who had done GLOBE activities with their students by that time.

Perceptions of Trained Teachers Who Have Not Implemented GLOBE with Students

Among the teachers in our survey sample, 35% did not implement the program with students during 1997-98. These teachers were asked to indicate the major barriers preventing them from implementing the program.

Perceived Challenges. Table 5.1 displays their responses, as well as those of an earlier sample of GLOBE-trained teachers who had not implemented the program when they were surveyed in 1996.

In the 1998 data, the barrier perceived as major by the largest proportion of teachers (52%) was finding a way to collect data on weekends and during vacations. GLOBE teachers commit to collecting data on a scientifically determined schedule on a long-term basis. Teachers who feel they cannot live up to this commitment may feel reluctant to start the program with their students. (In the 1996 survey of nonimplementing teachers, this barrier was not presented for rating.)

The responses for the remaining barriers follow the same general pattern as in the spring 1996 survey. The second most frequently cited major barrier was lack of Internet access. Despite the major increase in the proportion of U.S. classes with Internet access, 49% of the teachers who had not implemented the program with students cited lack of access as a major barrier (compared with 46% in 1996). Other technology-related barriers included lack of needed hardware and software (cited as major by 32%) and lack of technical support (cited by 20%).

After lack of Internet access, the next three barriers in decreasing order of importance all concerned time: first, the time needed to plan and set up for the program (cited as major by 47%); second, finding time for the program, given other curricular and testing requirements (46%); and finally, finding long enough blocks of time within the school schedule (41%).

Table 5.1
Problems Rated as "Major Barriers" by Trained Teachers Not Implementing GLOBE with Students
(Percent Reporting)

Barrier Rated as "Major"	*1998 Survey*	*1996 Survey*
Lack of good way to collect data on weekends/vacations	52	NA
Lack of Internet access	49	46
Difficulty finding time to prepare for implementing	47	37*
Difficulty finding time for GLOBE activities	46	37*
Difficulty fitting into school schedule	41	27
Difficulties integrating into existing curriculum	34	18
Lack of computer hardware/software	32	20
Difficulty identifying an appropriate site	25	13
Lack of technical support	20	12
Concern about whether GLOBE would be valuable for my students	4	4
Sample sizes:	$113 \le n \le 124$	$80 \le n \le 85$

NA = Not asked.

* In 1996, the single item "Difficulty finding time to plan and implement GLOBE activities" was used.

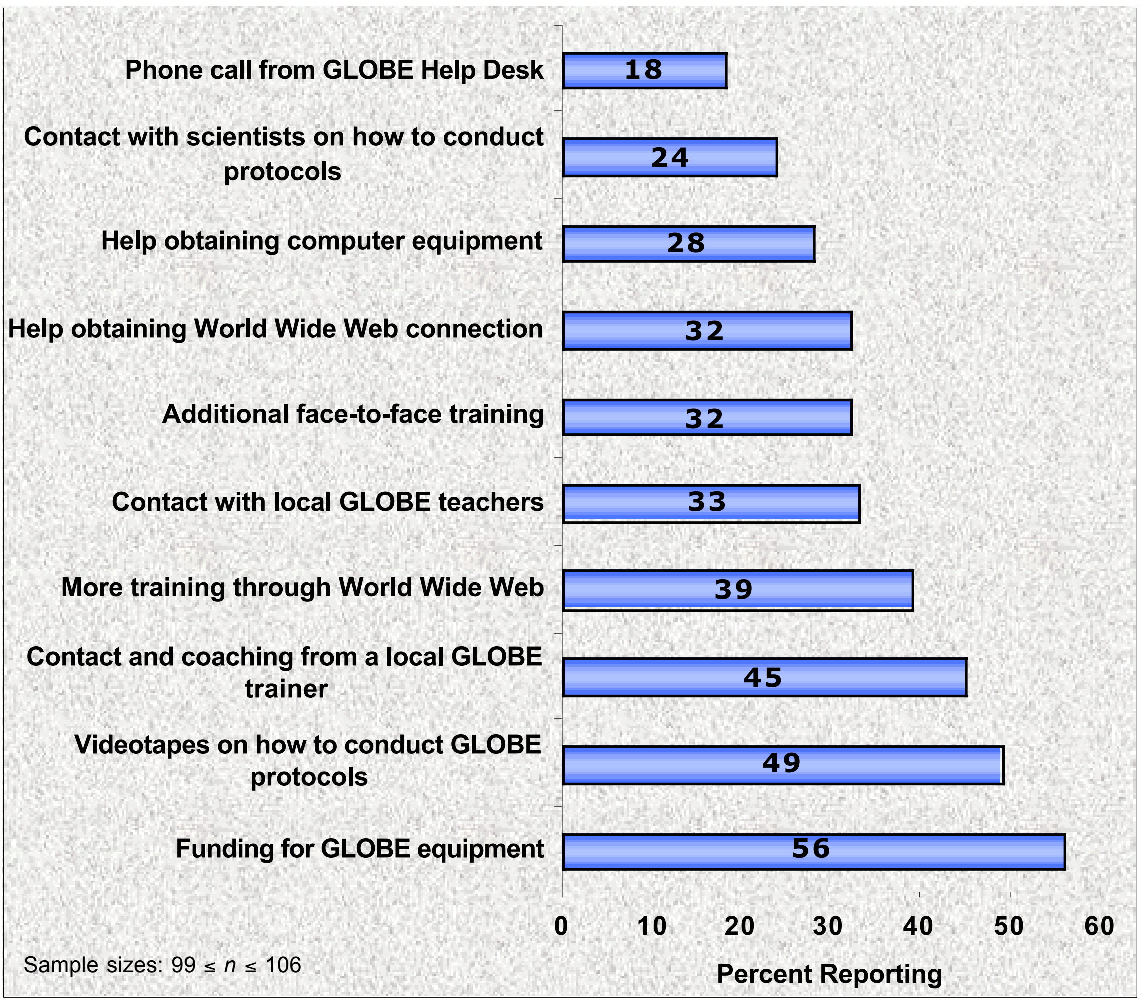
Fitting GLOBE into the existing curriculum was viewed as a major barrier by 34% of the teachers who had taken the training but not yet implemented the program with students. Difficulty finding an appropriate study site was rated as a major issue by 25%.

A positive sign for the program is that a very small fraction of the teachers (4%) who had failed to implement the program by the spring of 1998 cited concern about

GLOBE's value for their students as a major barrier—the same low percentage was found among nonimplementing teachers in the 1996 survey. Moreover, 84% of these nonimplementers reported that they expected to implement GLOBE with their students at a future time.

Desired Supports. Teachers who had not begun implementing GLOBE with students were asked also what actions the GLOBE program could take to increase the likelihood that they would implement the program with their students. Figure 5.1 shows responses to this item.

Figure 5.1
Actions That Would Increase the Likelihood of Implementation with Students



The form of assistance most desired by these teachers is funding for GLOBE equipment. Although efforts have been made to keep the equipment costs at a reasonable level ($395 for the elementary level and $595 for middle and secondary levels), 56% of teachers say that funding for equipment would be a "big help." In contrast, help in obtaining computer equipment was cited as a potential big help by just 28%.

The next most highly rated potential supports were all mechanisms for increasing these GLOBE-trained teachers' skills and confidence that they know how to execute the measurement protocols correctly. The most highly rated among these (considered a potential big help by 49%) was videotapes on how to conduct GLOBE protocols (19 such videotapes are currently under development). Almost as desirable from these teachers' perspective would be contact and coaching from a GLOBE trainer in their local area (45%). As discussed in Chapter 1, the move toward greater reliance on GLOBE "franchises" with regional responsibilities is intended to make such ongoing contacts more feasible. Thirty-nine percent of these teachers said they would like the option to take additional or refresher training through the World Wide Web. Contact with local GLOBE teachers was a support that 33% of respondents felt would be a major help; additional face-to-face training was rated as a major support by 32%. Twenty-four percent felt that contact with scientists on how to conduct the GLOBE protocols would be a big help.

Thirty-two percent also said that help with obtaining a World Wide Web connection would be a major support. This was one of the few supports about which teachers were asked also in 1996 and was the only one for which there was a major shift in teacher responses. In 1996, 48% of the trained teachers who had not yet implemented GLOBE said that assistance in obtaining their Internet connection would be a major help. Our interviews with teachers during the intervening years suggest that although many teachers do not have the Internet connections they would like to see in their classrooms, most of them have been promised connections and feel that it is a district or state responsibility to put those connections in place. A phone call from the GLOBE Help Desk was rated as a potential big help by just 18%, similar to the 19% rating obtained in 1996.

Perceptions of Teachers Who Have Implemented GLOBE with Students

Another perspective on the challenges posed by GLOBE is provided by the responses of those teachers who have been implementing only some of the GLOBE activities with students. We would expect these teachers to cite some of the same issues that were seen as barriers by those who had never gotten to the point of working with students on GLOBE, but with program experience, the hurdles to getting the program up and running initially may seem less daunting and additional issues may well increase in prominence.

Perceived Challenges. Table 5.2 presents the ratings that teachers who had implemented GLOBE with students in 1997-98 gave for the challenges they faced. The top five challenges in implementing GLOBE were the same for these implementing teachers as for those who had not yet used the program with students. Collecting data on weekends and during vacations was again viewed as the most serious barrier. A number of the other challenges were viewed as major by smaller proportions of the implementing teachers than of the nonimplementing ones. Lack of Internet access, finding time to prepare for implementing the program, integrating the program into existing curriculum, obtaining computer hardware and software, identifying an appropriate study site, and getting technical support loomed as larger challenges for those who had not started using the program with students than for those who had gotten it going. Table 5.2 also displays the barrier ratings of the subset of the random sample of trained teachers surveyed in 1996 who had implemented GLOBE with students. The 1998 implementing teachers' ratings were more similar to those of their counterparts surveyed in 1996 than to those of the nonimplementing teachers surveyed in 1998. One significant change in rated seriousness of a barrier was that for technical support. Fewer implementing teachers found lack of technical support to be a major barrier to GLOBE implementation in 1998 than in 1996.

Desired Supports. Teachers who implemented GLOBE during the 1997-98 school year were asked to indicate how much various supports would help them implement more aspects of the program in the future. The list of potential supports was similar to that rated by teachers who had not implemented GLOBE with students, and Table 5.3 contains both sets of ratings. For those supports rated by both sets of teachers, the rank order for the ratings is generally the same for the two groups, but usually with a somewhat larger proportion of the nonimplementers considering each support a potential "big help." The support in which the gap between nonimplementers' and implementers' perspectives is largest is "contact and coaching from a local GLOBE trainer"—which 45% of nonimplementers (compared with 27% of implementers) would deem a major support.

Table 5.2
Problems Rated as "Major Barriers" by Teachers Implementing GLOBE with Students
(Percent Reporting)

Barrier Rated as "Major"	***1998 Survey***	***1996 Survey***
Lack of good way to collect data on weekends/vacations	53	50*
Lack of Internet access	36	NA
Difficulty finding time to prepare for implementing	35	40
Difficulty finding time for GLOBE activities	44	42
Difficulty fitting into school schedule	35	45
Lack of computer hardware/software	22	25
Difficulties integrating into existing curriculum	19	20
Difficulty identifying an appropriate site	13	NA
Lack of technical support	12	24
Concern about whether GLOBE would be valuable for my students	3	NA
Sample sizes:	113 ≤ n ≤ 124	80 ≤ n ≤ 85

NA = Not asked.

*In 1996, the item had the more ambiguous wording "Accessing instruments for data collections on weekends, vacations."

Like the nonimplementers, those teachers implementing GLOBE with students were most likely to see videotapes on the GLOBE protocols as major assistance in helping them expand their GLOBE offerings (Table 5.3). Having another GLOBE teacher at their schools (a support not included on the list provided for nonimplementing teachers) was the next most desirable potential support—rated by 38% as a potential "big help" for implementing more investigations.

Table 5.3
Actions That Would Increase Breadth of Implementation by Teachers Implementing GLOBE (Percent Reporting)

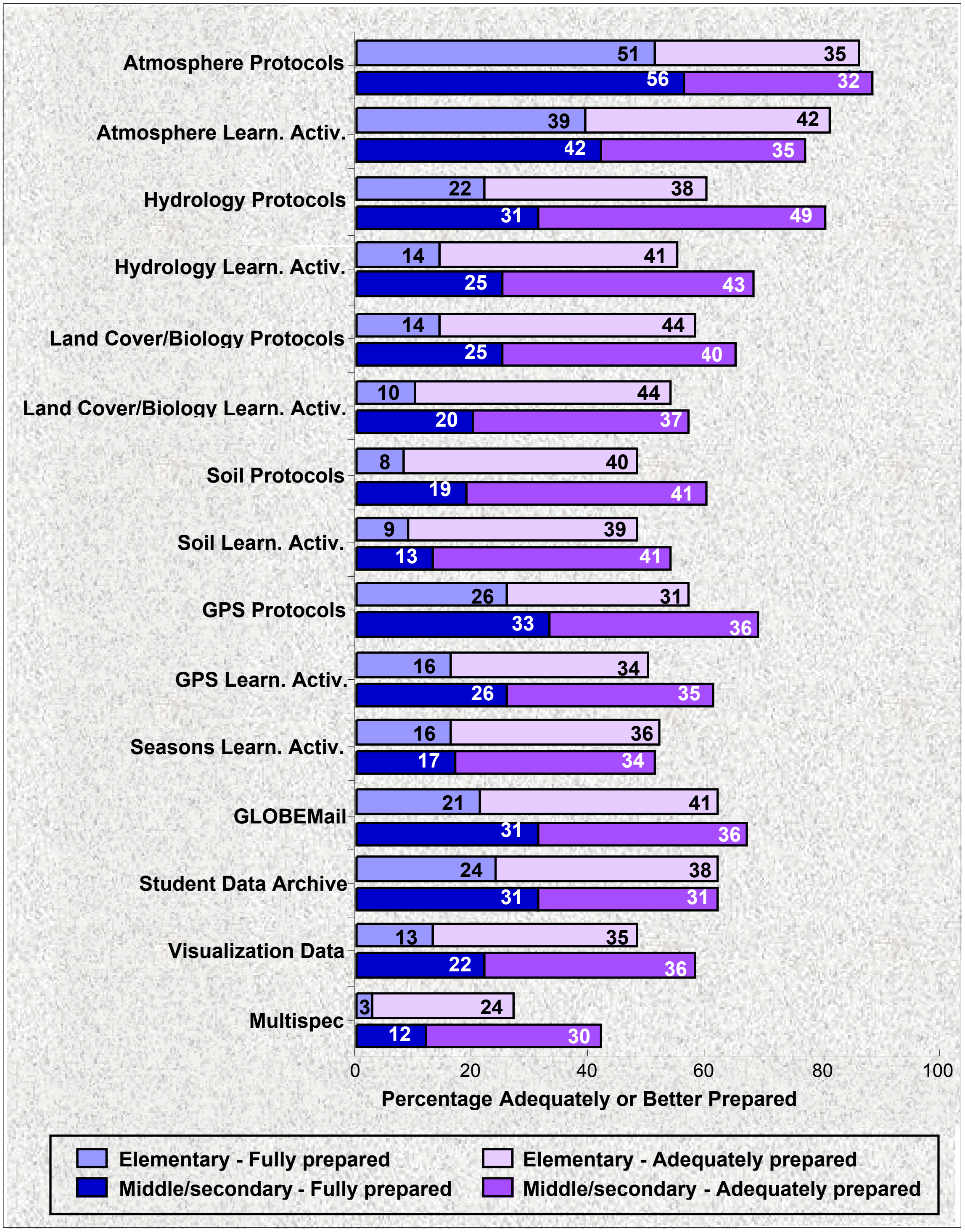
Action Rated as "Big Help"	*Implementers*	*Non-implementers*
Videotapes on how to conduct GLOBE protocols	48	49
Another GLOBE teacher at school	38	NA
More training through World Wide Web	31	39
Help obtaining World Wide Web connection	29	28
Contact with local GLOBE teachers	28	33
Contact and coaching from a local GLOBE trainer	27	45
Help obtaining computer equipment	22	24
Contact with scientists on how to conduct protocols	22	24
Phone call from GLOBE Help Desk	15	18
Funding for GLOBE equipment	NA	56
Additional face-to-face training	NA	32

Sample sizes: $99 \leq n \leq 106$
NA = Not asked.

Perceived Adequacy of GLOBE Training and Support Materials

Teachers implementing GLOBE with students were asked to rate how well GLOBE training and support materials prepared them for implementing various aspects of the program. Figure 5.2 displays the responses of elementary teachers separately from those of middle and secondary teachers. If the proportions of teachers feeling "adequately" and "fully prepared" are summed, the average percentage of elementary teachers who judge that their preparation was adequate or better is 62% for the data collection protocols, 57% for the learning activities, and 50% for the technology functions (e.g., GLOBEMail; use of data visualizations). The corresponding averages for middle and secondary teachers were 72%, 61%, and 57%, respectively.

Figure 5.2
Teachers' Perception of Their Level of Preparation for Implementing GLOBE Protocols, Learning Activities, and Technology, by Grade Level



The differences in these perceived levels of preparation make several points. First, perceived degree of preparation for the various protocols and learning activities is positively associated with the likelihood that those portions of GLOBE will get enacted. The protocols and learning activities implemented by the highest proportion of teachers are also those for which teachers report feeling best prepared. Nevertheless, the proportion of teachers who feel adequately or better prepared to implement Hydrology, Land Cover, and Soil protocols far outstrips the number actually implementing them. Second, for 12 of the 15 components rated, elementary teachers feel less well prepared than middle and secondary teachers, even though both groups have gone through the same training. Clearly, some individuals will need more training than others to obtain the same level of preparation and comfort. Third, comfort levels are highest with the protocols and lowest with the technology functions. It is not clear to what extent this pattern reflects differences in prior preparation versus differences in the amount of emphasis given these three areas in the training. Finally, teachers' feelings about their preparation for implementing learning activities parallel those for protocols: the relative rankings of the investigation areas by perceived level of preparation are the same for both.

International and Franchise Partner Strategies for Addressing Challenges

By its third year of operation, the GLOBE program had evolved considerably from the first year, when all the U.S. teachers who were trained received their training from trainers hired under contract. Increasingly, it is a minority of teachers who receive their GLOBE training from "contract trainers"; the majority of teachers now receive training provided either by international partners or, in the United States, by GLOBE "franchises." Although GLOBE trains the trainers used by its international and franchise partners and holds them responsible for fidelity to the data collection protocols, it leaves specific decisions as to teacher recruitment, training duration and format, and other support activities up to the partner organization. International partners and U.S. franchises have developed a variety of strategies for training and supporting teachers. Some of these strategies are reviewed below in light of the supports that teachers rated as most desirable on our survey.

Help Obtaining Equipment, Computers, and Network Access. Many international partners felt it was necessary to provide the GLOBE instruments and, if necessary, computers and Internet connections to their first cohort of GLOBE schools. In Egypt, for example, the Ministry of Education put GLOBE schools at the top of their list for government-provided Internet access. In Germany and the Czech Republic, all GLOBE schools are provided with the needed computers and Internet access through a combination of government funding and private donations. In the United States, the Arkansas franchise (operated by the University of Arkansas) provides an equipment package for the teachers going through their GLOBE training, funded primarily with Eisenhower professional development funds. Similarly, the Maryland/NASA Goddard franchise is providing instruments to the schools undergoing their GLOBE training. The University of Alabama in Huntsville franchise provides GLOBE measurements and training materials for districts with 20 or more teachers going through a week-long workshop.

Ongoing Technical Support. Many schools have acquired Internet access expressly for the purpose of participating in GLOBE, and technical support for setting up their infrastructure is not always readily available. A number of international and franchise partners have taken steps to augment the assistance available to all GLOBE schools through the Help Desk. In the Netherlands, for example, the GLOBE program is partnering with a computer firm that gives technical advice to schools concerning their computer and network infrastructure. Lynne Hehr of the Arkansas franchise encourages the teachers she has trained to e-mail her with any technical problems they are encountering. In some cases, Hehr can suggest a fix; in others, she puts the teachers in contact with someone at the Help Desk or elsewhere in GLOBE who can help them.

School Team Model. Although the GLOBE program has been encouraging the training of multiple teachers per school since 1996, contract training is open to any teacher who registers. International and franchise partners have been able to go farther in defining their mission as working with teams of teachers rather than single teachers per school. The program in the Czech Republic (run by Tereza, a nonprofit, nongovernmental organization) was among the early proponents of a school team model. Tereza recommends that teachers form teams to implement GLOBE and spread the data collection across different groups of students taking measurements during different time periods. In Greece, a school must send two teachers for GLOBE training in order to participate. Denmark trains interdisciplinary teams of three to six teachers per school. Ireland's model is to train one computer science educator and one science educator per school. Finland has set the target of training five teachers per school. In the United States, the New York Orleans-Niagara BOCES franchise has received a Goals 2000 grant to work with interdisciplinary teams of teachers. The Arkansas franchise reports that about two-thirds of the teachers it trains are part of multiperson school teams. The University of New Hampshire franchise is extending the team model to the district level. It is promoting GLOBE to additional schools from districts that already have an active GLOBE school.

Pacing of Training Content. International partners and U.S. franchises use a wide variety of training schedules. In the Czech Republic, for example, teachers in training spend 3 days on protocols and learning activities, 1 day with computers and an introduction to remote sensing, and a final day for a fun "examination" on all the content. Finland has teachers attend an initial 1-day training session and then return about 4 months later (hopefully after implementing their initial investigation) for 3 days of training. Costa Rica offers teachers four Internet workshops, a half day each week for a month, and 3 days of training on how to take the GLOBE measurements.

The Arkansas franchise was a pioneer in going to 3 days of "core" GLOBE training, with an optional fourth day for review of the basics or training in more advanced material. Lynne Hehr's argument for such a schedule on the GLOBE trainers' listserv, in fact, was a catalyst for a move to a similar schedule in the contract-provided training.

Refresher Training. Many of the international partners planned for multiple training sessions from the program's inception in their countries. In the Netherlands, teachers who have received their GLOBE training are invited back for a "Teacher Day," where they can meet with other GLOBE teachers to discuss their successes and challenges with implementing GLOBE. After training its first cohort of teachers, the Czech Republic held a meeting in November 1996 for teachers and principals from 22 GLOBE schools, who came together to share their schools' experiences, identify common problems (e.g., fundraising), and work in smaller teams for brainstorming strategies. Finland hosts GLOBE seminars for 50 teachers twice a year. In Madagascar, the GLOBE Program hosts visits (provides food and lodging) for teachers to come to the capital city to discuss their implementation of the program. They are also planning to provide funds for teachers to visit exemplary GLOBE schools within different regions of their country. In the United Kingdom, a local regional trainer visits GLOBE schools and discusses the program with their teachers as a strategy for keeping them engaged. Also, a series of regional training events were planned for October 1998.

Within the United States, the University of New Hampshire franchise is pioneering a new model for supporting previously trained teachers. It is seeking to reach the 40% of

GLOBE-trained teachers in New England who are not currently providing GLOBE data. State teacher support groups will meet two evenings a month. Those teachers who attend the meetings and begin reporting data can receive credits from the University of New Hampshire. Lynne Hehr, of the University of Arkansas franchise, views keeping track of the progress of her teacher trainees as part of her job. If teachers are not participating, she contacts them and asks what help they need. In Alabama, the state department of education is funding a position to provide ongoing mentoring and staff development for the state's GLOBE teachers. Follow-up workshops for GLOBE teachers are planned to start during the 1999-2000 school year.

Additional Training Materials and Support. In addition to such meetings for reflection or follow-up training, a number of GLOBE partners have produced their own training follow-up materials. The Netherlands has prepared and distributed four brochures with practical suggestions for implementing GLOBE. For fall 1998, Lynne Hehr of the Arkansas franchise plans a monthly newsletter, with each issue focusing on a selected protocol and discussing problems or mistakes that she sees frequently in her visits to GLOBE schools.

Drexel University is starting a charter school on its campus that will serve as a model GLOBE school. Drexel undergraduates will be able to fulfill their service learning requirement by serving as GLOBE mentors at the school. The Director of the Teacher Center running the New York Orleans-Niagara BOCES franchise is making himself available to team teach with GLOBE teachers as they try out new protocols.

Increased Contact with Scientists. A number of GLOBE partners are taking on the challenge of increasing contact between students and scientists. A recent good example was the October 3, 1998, "MUC-a-Thon" in which the Duchess County Community College GLOBE franchise organized GLOBE students, teachers, and parents in classifying the land cover for 92 sites within the Mid-Hudson Valley region of New York. The Alabama GLOBE franchise has set the goal of having a scientist available to help provide support to every GLOBE school in the state. Scientists are being recruited from universities and other agencies. Informal science education institutions, including the Botanical Gardens in Huntsville and Birmingham, have begun to participate.

The Costa Rican model is to pair each GLOBE school up with a nearby science institution, in order to have close-by scientific expertise and assistance. The Netherlands held a research contest for GLOBE students: 10 teams of young scientists submitted research reports for review by a panel of Dutch scientists. The teams also presented their work at the GLOBE Learning Expedition student conference in Finland.

Conclusion

GLOBE continues to be a challenging program to implement, and teacher survey responses indicate that both the team approach and continued contact with GLOBE experts and colleagues are valued supports. Franchise and international partners are exploring a variety of strategies for supporting their teachers. As GLOBE partners continue to increase their involvement and try out new strategies, it will be important to identify and promulgate successful ones.

Chapter 6. Influences on Students

One of the goals of the GLOBE program is to integrate the work of scientists, teachers, and students in research investigations that will lead to a better understanding of the global environment. In response to first-year experiences that suggested "a need to ensure that data collection did not get divorced from conceptual learning" (Means et al., 1996), the GLOBE program has worked to create learning activities that would provide a meaningful context for students' collection of data. The development of learning activities was important for the success of the GLOBE program, which was always intended to go beyond having students simply reporting data. In the Year 2 evaluation, we compared GLOBE students' performance with that of non-GLOBE students on fairly standard (multiple-choice) science assessments. In Year 3, we undertook a less structured examination of the nature of students' understanding of environmental science concepts, by analyzing students' reasoning while they conducted GLOBE activities.

Opportunities to view students' thinking and reasoning about GLOBE concepts occur when students are asked to explain and justify what they are thinking while performing a scientific task (Coleman, 1998). During our visits to GLOBE sites, we create "evaluative learning opportunities"—moments when we interview students while they are working on GLOBE activities in class or on field trips as they take measurements. In the first part of this chapter, we report students' responses to these learning opportunities as evidence of GLOBE's influence on students' reasoning and understanding of environmental science. By way of illustration, we cite examples of students' reasoning in multiple contexts in school, after school, and during particular GLOBE field trips. We also highlight the importance of personal knowledge, awe, and curiosity, and the role of scientific inquiry in developing students' understanding of science in GLOBE.

In the second section, we report the results of a pilot study designed to examine GLOBE students' environmental awareness. In the final section, we present quantitative data derived from our teacher survey to examine teacher beliefs concerning GLOBE's impact on students' learning.

Supports for Students' Reasoning

Students are often unaware of the nature and purpose of learning activities. When asked to explain what they are doing, they frequently resort to retelling the steps and procedures that were taken (e.g., measuring something) rather than explaining or justifying the selection of those steps and not others. Such responses do not mean that the students have no ideas about why they are collecting particular kinds of data, however. Additional probing often elicits students' understanding or misunderstanding concerning the goals and significance of their data. During one interview, for example, a fifth-grade GLOBE student from Ft. Lowell Elementary School was asked a question that required her to explain what she was doing as she tested the turbidity of her water sample. Her initial answer included statements about taking the turbidity measurement. With additional probing by the interviewer, the student provided several statements to explain what the measurement of water turbidity meant to her and why it was important for her environment. The following is an excerpt taken from her discussion with the interviewer:

Interviewer: "Can you tell me specifically what you have on your sheet and why you have been filling out this information?"

Student: "Um.. the turbidity is a little tube where you see how clear the water is and then there's the pH that sees….um.. if there's more acid or alkalinity in the water, and then the TDS [total dissolved solids] sees like how many—how much minerals and stuff are in them."

Interviewer: "And what would the turbidity tell you? In other words, why would it be important if the water was clear?"

Student: "Um.. to see how much sunlight can get into the water…to see how many plants and things can grow in there."

Interviewer: "So what do you think? If it's clearer then more plants or if it is cloudier then more plants?"

Student: "Clear it is more plants 'cause a lot of plants need a little bit of sunlight and if it's really cloudy you can't get a lot of sun."

Interviewer: "Why?"

Student: "Why what?"

Interviewer: "I think that you are right. I'm wondering why if it's cloudy, why would it be harder for the plants to get sunlight?"

Student: "Because the sunlight can't travel through all of the dust and whatever is in the water."

The purpose of this example is to illustrate the importance of helping students become more aware of the concepts underlying GLOBE data collection tasks. We believe that there are several ways to achieve this goal and highlight three potential strategies that enable students' reasoning about the complex ideas underlying GLOBE measurement activities.

Developing Personal Knowledge

Having personal experience taking GLOBE measurements appears to play an important role in building expectations concerning events and patterns in students' environments. In the excerpt below, a fourth-grade student is at one of her hydrology stations taking the temperature of water that has been collected from a nearby stream. She is asked by the interviewer to explain whether the temperature is what she expected. Her explanation reveals the importance of her having had personal knowledge of taking the temperature of the stream on previous days.

Interviewer: "Okay, so what did you find?"

Student: "I found 81."

Interviewer: "Eighty-one. But what does that mean, you found 81?"

Student: "Um... the temperature, we had to hold it into the water and we got 81."

Interviewer: "Okay, so was that what you had predicted it would be? Is that surprising to you or is that just what you expected?"

Student: "Just what I expected."

Interviewer: "Why?"

Student: "Because, um, I, whenever I felt the water before, whenever we were getting water samples I knew that it wasn't going to be like, really really low."

Interviewer: "Low?"

Student: "Yeah, 'cause it was—it was kind of warm."

Interviewer: "It was warm?"

Student: "It's always warm because it comes from a spring over there." [She points to the spring.]

A similar reference to the importance of students' personal knowledge was suggested during an interview with the student's teacher, Mary Bouley. Bouley emphasizes the importance of students' forming personal relationships with GLOBE measures and data. To illustrate her point, Bouley described an event that took place while one of her students was asked to report at one of their teacher conferences. During a teaching and technology conference, one of Bouley's students was asked to explain what they do in the GLOBE program. The student told the audience about her personal experiences and feelings about taking different measurements of rainwater and temperature with other students in her school. Bouley described the students' GLOBE experience as a "precious moment" in their lives because in taking GLOBE measurements, the girls came to feel a personal connection with the rainwater. In particular, she remarked:

> *"I mean, these girls have a relationship with rainwater like nobody else in the building, and forever and ever, while during their whole lives, when it rains, their whole sense of what rain is—is completely altered because they have had this intense relationship with it."*

At Randolph Magnet, an urban elementary school in Chicago, a group of fifth-grade students went to a field station at a local park to take water measurements. Their teacher, Gregory Lopatka, who implements GLOBE primarily as an after-school club, worked with the students at their stations. The interviewer asked one of the students whether it is nice to be able to come outdoors to collect GLOBE data. The student replied, "Yeah, especially because I can't read, because I can't read what they are doing." After further discussion, the student clarified that unless he is able to do the activity for himself, he is unable to understand what the readings mean.

Doing science for themselves not only allows students to understand the processes or steps required to test something, it can also affect the nature of the content knowledge students acquire. In an interview with a group of sixth-grade students at St. Peter's Catholic School, a girl told the rest of the group that she made a mistake during one of their investigations when she was testing the soil for its pH. She learned that she should never touch the soil with her hands because "your hands may have a different pH level." It is unlikely that this learning opportunity would have arisen had she not had the chance to touch the soil for herself as she took the measurements.

In a separate focus group discussion with a group of fifth-graders, a student revealed to the rest of the group that he sometimes shares his new knowledge with his mother. He explained that his mother doesn't always know about many of the ideas that they learn in GLOBE, and he enjoys teaching her what he knows. He stated "Well, first I asked her if she knew what it was and she said, 'no,' so I just decided to tell her things about the pH and TDS because she didn't know what they were about."

The excerpts from Ft. Lowell, Randolph Magnet, and St. Peter's reveal the importance of students' learning by developing personal knowledge of science as they participate in the GLOBE data collection process. Students appear to form an intimate understanding of what it means to do science and become more aware of the nature and purpose of what they are learning in ways that facilitate sharing their knowledge with family members and other adults and students.

The Importance of Awe and Curiosity

Another important support for students' learning is their tenacity to search for explanations to problems that are puzzling to them. Here, student learning occurs through deliberate problem-solving rather than as a by-product of their activities (Bereiter, 1992; Bereiter & Scardamalia, 1992; Voss, 1988). In the following excerpt, a student discusses an experience that challenged her everyday understanding, a problem that contributed to advancing her understanding of the principles and concepts of the domain of ecology.

Agua Caliente Park, a beautiful oasis in the Sonoran Desert in Tucson, Arizona, is the hydrology site for Ft. Lowell Elementary students. At one of their stations, a third-grade student wanted to explain something about the turbidity measurement that was puzzling to her. Wondering about the pattern of turbidity measurements taken at the stream led her to try to reconcile how something that appears one way can actually mean something else.

This is an important principle for understanding science and for motivating the use of standardized, quantitative measurements—a discovery that is quite remarkable for a third-grade student. The following is an excerpt from her discussion with the interviewer as she took the interviewer aside to tell her that she had discovered something new.

Interviewer: "Okay, so what did you find?"

Student: "It's like totally clear!"

Interviewer: "Say that again?"

Student: "Okay, whenever we are doing the turbidity, I noticed that um...whenever we came here first it was like it was like a grayish color, but whenever we did the turbidity [test] it was like over 120, so that means that it's really clear."

Interviewer: "Okay, that's great."

Student: "So, it's like really weird *because it's like what we see might not be the real truth* because um… if you see it from like a really far-away distance,

> it looks really dark, but if you like go in—if you're like in the water, it's really light."

We are not arguing that this particular scientific principle could not have been learned elsewhere (e.g., in her regular science class), but it is easy to appreciate that without the many visits to the stream and the continuous data collection and analysis, her important discovery might have emerged much later in her scientific studies or not at all.

At another site, a fourth-grade boy named Lewis was retrieving a water sample for a particular GLOBE test. He thought that it would be a "cool idea" to compare the pH of a water sample taken from an area in the pond that was thick with algae and other small plants with water samples that they had taken earlier. He stuck his hand into an area of the pond that contained so much algae that neither he nor his classmates who were watching him could see what was in the water. Two of the girls in his class squirmed in disgust at the thought of touching the slimy green water. The interviewer laughed and asked Lewis why he would stick his hand into greenish water when he couldn't see what was there. He replied, "'Cause it feels good and you never know what you will find." It seemed that Lewis's decision to sample the pond water was driven, at least in part, by his curiosity about the unknown.

Promoting Scientific Inquiry

A third strategy for promoting students' science reasoning is to involve them in authentic investigations. As students gain personal knowledge and treat learning as problem-solving, they are likely to gain both the skills and the motivation to mount their own inquiries. Having students participate in GLOBE investigations is one important way to do this.

During a class observed at St. Peter's Catholic School, a sixth-grade student told his classmates that he was interested in conducting his own investigation on soils. He said that he had been wondering why soils are more or less acidic when they come from different places near his house and school. His classmate remarked that she was also interested in his soil investigation and had been trying to understand why the soils have different colors and whether particular soils are better for growing certain plants. Together, they shared their ideas and strategies for seeking answers and explanations for their questions.

In the same class, during a focus group discussion, one of the students' remarks reflected not only the differences between GLOBE and more traditional science class activities but also the student's growing appreciation of the nature of scientific inquiry and debate:

> *"In GLOBE you get to have your own ideas, whereas in textbooks they give you the facts and you are supposed to just go by the facts…. But some people think differently, and when you are in GLOBE you can just sit down and say, 'Well, if one scientist says something,' you can say, 'Well, I don't think so' or 'I agree with that' and express your own opinions and then check things out."*

This particular student had already recognized that science is not just about learning facts and that there are multiple ways of thinking about scientific problems. Furthermore, his remarks show that he regards research (i.e., "checking things out") as a strategy for deciding which ideas are more viable than others.

At Talley Middle School, Conrad Rice teaches GLOBE as a volunteer after-school club. Many of the students in the club are also enrolled in his eighth-grade earth science class, where they have been learning about the Earth's dynamic crust and its relation to earthquakes. Rice is able to integrate the work that he does in his class with the work that the students do in the GLOBE club by having students construct experiments. During an interview, Rice stated that he wants his students to "go beyond the data-gathering stage and to be able to dig deeper into the reasons behind the data." Consequently, he creates situations in his class where students design their own experiments.

In one of Rice's classes, the students we observed were conducting an experiment comparing different types of soil that would be more or less suitable for a building site and offer different degrees of foundational support for a building during an earthquake. His students compared soils that contained different amounts of water, gravel, and sand. The students had to test different soils and design a building to withstand a simulated earthquake. They built structures on top of each type of soil and simulated an earthquake by shaking the tables that supported their building structures. According to Rice, the students that were involved in the GLOBE club were able to apply their knowledge from the soil work they had done previously in the club and made many insightful predictions about whether it would be better or worse to build on bedrock versus saturated sand. He feels strongly that designing experiments is a great way for his students to learn. Rice's application of the soil work in GLOBE to his earthquake-proofing experiment in class was also a good example of how GLOBE activities can be connected to a teacher's specific science curriculum.

Experimentation is seen as an integral part of the process of learning science in GLOBE. The data that students collect can be understood only in terms of the research questions that are being investigated. The following description of two teachers collaborating to design a study of soils with 27 first-grade students illustrates this point. In a first-grade class at Ft. Lowell Elementary School, teacher Delores Otañas Knox collaborated with GLOBE teacher Jerry Carney on an adobe brick building experiment. Since Carney was already studying soils with his GLOBE students, he agreed to help the younger students conduct a study comparing different recipes for adobe. Knox's father had been an adobe brick builder, and she had written down several of his recipes for making bricks for her students to test. Teams of first-grade students made their adobe bricks by following an assigned recipe that required mixing several ingredients (e.g., sap from boiled prickly-pear cactus, dried-up horse manure, and water) in specified proportions. Each team of students had a different recipe to follow, and the purpose of their experiment was to determine which recipe produced the most durable adobe brick (see photos in Figure 6.1).

Figure 6.1
Adobe Bricks Made by Fort Lowell Students

Figure 6.1 (Concluded)

After the bricks had dried, Carney and the 27 first-graders took all of the bricks that had been created and devised a method to test for water absorbency and durability. Each student weighed each brick when it was dry (dry weight) and again after it had been submerged in water (wet weight). Carney helped the students calculate the adobe moisture using the soil moisture formula presented in the GLOBE Teacher's Guide. Everyone was amazed with the results because the brick that absorbed the most moisture was the traditional burned adobe brick. Surprisingly, the brick made with cactus sap (Knox's father's recipe) also absorbed a lot of water, but, more importantly, it dried very quickly without crumbling as the rest of the bricks did. Knox conveyed her excitement over the results of the experiment to her students, "Can you imagine? You could actually water your house, and it stays cool inside and the bricks dry very fast."

According to Knox, "The students were very excited about their recipe being the best, but most importantly it was great to have a GLOBE teacher join me because joining with GLOBE allowed my students to get the science part of it." Both Knox and Carney were amazed at "how well the students were able to do a lot of comparisons."

This observation makes several points. One, it illustrates how a GLOBE teacher can collaborate with another teacher in his school and apply ideas from the GLOBE program to projects that were not initially developed for science. Second, it shows how students as young as first-graders can follow the logic of an experiment, comparing several different samples and constructing an understanding of a "fair test." Third, it provides an example of how science can be integrated with culturally relevant artifacts (e.g., adobe building) to form instructional units that are relevant for students in multiple ways.

So far, we have described students' reasoning and understanding as verbalized in the context of their regular school and GLOBE activities. In the next section, we describe a pilot study that was designed to explore GLOBE students' environmental awareness.

Environmental Awareness Pilot Assessment: Students' Discourse about Earth Systems

In addition to increasing students' knowledge of science and mathematics, GLOBE has the goal of promoting students' environmental awareness. The phrase "environmental awareness" is open to many interpretations. One interpretation is knowledge of or concern about particular threats to the environment (e.g., depletion of the ozone layer). A second is environmental activism. For the purposes of the GLOBE evaluation (in keeping with GLOBE's emphasis on providing the scientific knowledge needed to make decisions about the environment rather than promoting particular "pro-environment" activities), we interpret environmental awareness from a cognitive-scientific perspective, as described below.

There is evidence in cognitive science research that background knowledge (sometimes referred to as prior knowledge) can have profound effects on the way new information is understood and used to construct new knowledge (e.g., Anderson, 1978; Voss, 1984). In particular, it has been demonstrated that a person's background knowledge can affect the way new information is comprehended by determining what elements are attended to as significant and how elements fit together (the basis for inferential reasoning). Studies examining expertise show that experts perceive situations in terms of patterns not discerned by novices (Chi, Glaser, & Farr, 1988). Using cognitive theory as the foundation for our research, we define environmental awareness as *a scientifically informed perception and recognition of the environment as a coherent set of interdependent and interconnected adaptive elements*. By highlighting the role of students' knowledge in their perception of the environment, we investigate whether students are able to integrate their knowledge of the environment in ways that model and explain Earth systems.

Typically, GLOBE students are taught to make observations and to learn how to use the scientific protocols for taking reliable measurements of their local environment. It would be possible to do this without integrating the experience with knowledge of environmental science in any systematic way. Therefore, we are interested in knowing whether GLOBE students have sufficient background knowledge to make inferences about an environmental scene and what kinds of supports or conceptual "scaffolds" they need to help them do so.

We designed a pilot study to examine students' qualitative understanding of ecology. Specifically, we compared the discourse and reasoning of small groups of GLOBE and non-GLOBE students as they responded to an ecology visualization task. Two research questions were asked: (1) whether GLOBE students are more likely to make environmental inferences about Earth systems than students who have not participated in the GLOBE program, and (2) whether GLOBE students can reason and make inferences about the environment with less adult support.

Method and Procedures

Thirty-eight fifth- to eighth-grade students enrolled in eight classes within five different elementary and middle schools in diverse settings participated in this study. Three facilitators were trained to use a structured prompting procedure. We observed and tape-recorded eight groups of students (six GLOBE and two non-GLOBE) as they worked together on the environmental awareness task—describing what they perceived or inferred to be present in a photograph of a natural environmental scene.

Students were given a picture of Glacier National Park (see Figure 6.2) and asked a series of open-ended questions about the image. The purpose of the interview was to provide students with an image as a "conversational prop" for facilitating their thinking aloud and offering elaborations about the environment. In particular, we were looking for evidence that students held an integrated Earth systems understanding of environmental science (e.g., statements about environmental variables as interdependent, adaptive, and cyclical).

Figure 6.2
Image of Glacier National Park

Environmental Inferences. We analyzed the students' interviews for instances of "environmental" inferences and explanations. All of the students' utterances were divided into idea statements, and then we identified occurrences of environmental inferences. Environmental inferences were those statements that included any interpretive reference about the environmental scene (e.g., "that must be a lake"). The environmental inferences were then coded as either "higher-level environmental" or "descriptive."

Since we were interested in finding evidence of students' understanding of Earth systems, we defined higher-level environmental inferences as statements that referred to any of five underlying ecological themes or "big ideas": interdependence, adaptation, cycles, ecosystems, and pollutants. These themes represent an Earth systems approach to understanding ecology (Skinner & Porter, 1995; Van Cleave, 1996).

- *Interdependence* is the idea that the elements are interconnected, that a balance exists within the environment. It includes any reference to or evidence of seeing "patterns" within the environment.

- *Adaptation* refers to ideas about how organisms adapt to their environment—for example, a physical characteristic or behavior that allows an organism to adjust to or accommodate certain conditions of a particular environment.

- *Cycles* refer to the idea that all components of the Earth's biosphere are used and reused. One example is the water cycle—the continuous movement of water between the Earth's surface and the atmosphere. The oxygen cycle refers to the idea that all animals and plants live within the Earth's biosphere, which extends just above and just below the Earth's surface. Gases in the Earth's atmosphere, water, etc., can all be reused by organisms because they are recycled. For example, plants and animals recycle resources in the atmosphere through respiration (in animals) or photosynthesis (in plants).

- *Ecosystems* refer to the idea that there is a distinct area that combines living (biotic) communities with nonliving (abiotic) environments such as sunlight, soil, moisture, and temperature, and concern ways in which they interact.

- *Pollutants* refer to what happens when contaminants are introduced into the environment (substances that destroy the purity of the water, air, and land).

Examples of *higher-level environmental inferences* include the following statements made by different students during their interviews.

"You can tell by the plants that the soil is very rich, and in the mountains it is probably very 'blocky soil' and 'prismatic,' but you can tell by the trees that the soil is very rich and, um, and you can grow lots of crops because you can see the lake right there that gives it moisture to keep on growing so it won't dry up like a desert." (Inferences: interdependence between richness of soil and tree growth; water cycle—moisture from lake.)

"Well, I see a lot of life...like, there's the trees are alive, and there's probably lots of things living in the water. And there's the grass or something right there. The grass is alive, and there's probably crickets and stuff…." (Inference: interdependence between water and insects, life.)

One student stated that the image looked “balanced.” When prompted to explain further, the student stated, “Well, I mean this is kind of the symmetrical thing, but everything is happy and balanced; there’s sort of like a perfect natural environment.” (Inferences: interdependence; ecosystems—balanced, perfect natural environment.)

Another student explained how the elements were interconnected by explaining what would happen if an airplane crashed on one side of the mountain. “Well, if it [referring to chemical spillage from the airplane] goes into the water, then the water will come up into the clouds and then the clouds will pour down acid rain, and the whole cycle of things and then the acid rain will go into the trees and then the trees will decay and it will go back into the ground. And some of the ground probably with erosion will go back into the water, and then the water will rise up again.” (Inferences: water cycle, pollutants.)

Descriptive environmental inferences are statements that refer to any superficial characteristic of the nature scene itself without making references to any underlying ecological ideas. For instance, when prompted to identify “ecological patterns” found in the image of the nature scene, many students referred to basic ideas about object, color, shape, or similarity to other places. For example:

“There is a lot of green in the picture [when referring to the trees].”

“It kind of looks like Agua Caliente Park ’cause it has the lake and it has a lot of trees.”

“That tree or bush looks sort of like that mountain” as he pointed to the contours of the outline of the trees and mountains presented in the image.

Scaffolded Prompts. Facilitators were trained to use a scaffolded prompting system to sustain and guide students’ discussion during the interview. In particular, the facilitators offered specific to general levels of support, depending on what was needed to sustain and advance students’ inferences and explanations. Three levels of prompts were developed and offered by the facilitators as supports for students’ thinking. Facilitators were instructed to begin by providing general support to students and to increase support as needed.

The first level, *general prompts*, were those intended to query students for more information with the least amount of guidance, interference, or directed support. For example, the following prompts were coded as general prompts:

"How do you know that?"
"Okay, anything else?"
"Can you explain what you mean?"
"Can you tell me a bit more about what you are thinking?"
"What else do you see?"

The second level, *reiterative prompts*, were those intended to guide students' reasoning by reiterating an idea that the student had already mentioned. In this way, the prompt encourages further elaboration of an idea previously stated by the students. Examples of prompts coded as reiterative include:

> *"So, the soil you said would be rich with nutrients, and how would you know that?"*
> *"You said 'clumpy'; we didn't talk about how the soil would feel, the texture."*
> *"That's a good point, what would run off?"*

The third level, *specific prompts*, were those designed to provide the most guidance and directed support for students' thinking about particular ideas, regardless of whether the ideas were raised by the student. These prompts were also used to bring students' reasoning back "on track" and to sustain their thinking about the environmental awareness task. Examples of specific prompts include:

> *"What about the soil on the mountains?"*
> *"And what makes it gray?"*
> *"Can you give me an example of moisture that is not cold?"*
> *"How would the gases get up into the air?"*

We transcribed and analyzed the conversations between facilitators and students, coding for occurrences and uses of the various levels of prompts. The following excerpt is an example of a student's discourse during an interview and provides an illustration of how the prompts were coded. In this sequence, a student named Alexis is drawing inferences (from the image) about the amount of water and moisture that exists in the nature scene.

Alexis:	Line	39.00	"Well, it seems like there's a lot of water here	
	Line	40.00	and a lot of moisture	
	Line	41.00	and they also get like the air is humid"	
Exp:	Line	42.00	"Uh-huh"	**General prompt**
Alexis:	Line	43.00	"Because of the moisture."	
Exp:	Line	44.00	"Okay"	**General prompt**

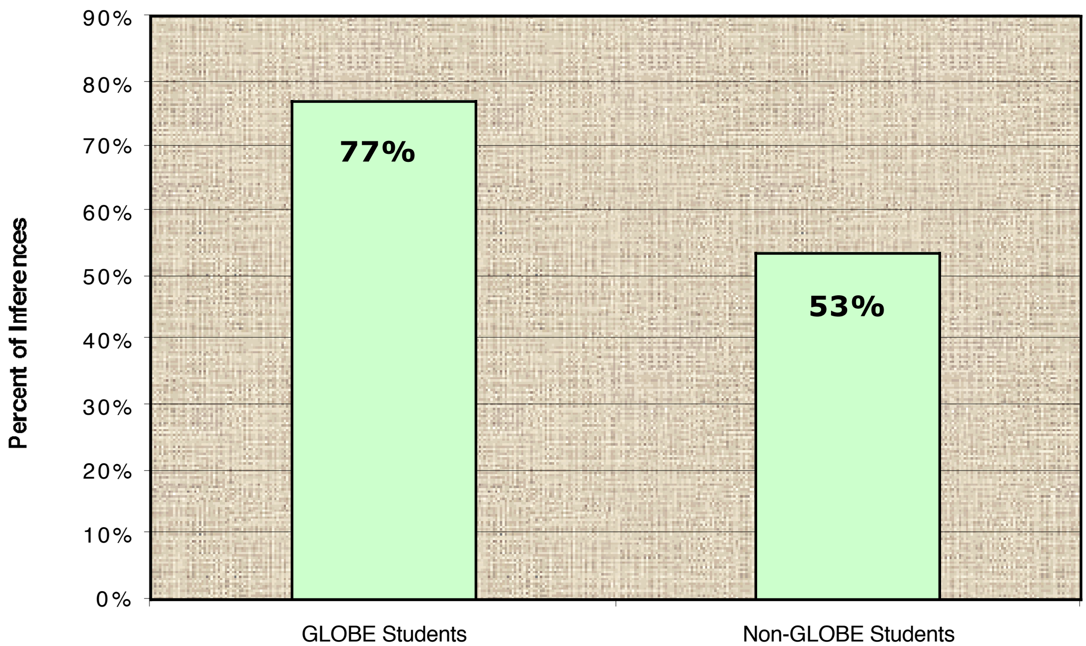
Alexis:	Line	45.00	"That will keep the soil good."	
Exp:	Line	46.00	"Uh-huh"	**General prompt**
	Line	47.00	"How do you know there's a lot of moisture	**Reiterative prompt**
	Line	48.00	and a lot of cold?"	**Specific prompt**
	Line	49.00	"How do you know that by looking at this picture?"	**General prompt**
Alexis:	Line	50.00	"Um…well, there's white stuff on the mountain."	
Exp:	Line	51.00	"What is the white stuff?"	**Reiterative prompt**
Alexis	Line	52.00	"Snow."	

Preliminary Results and Conclusions

Analyses of the coded pilot data found that, overall, a significantly higher portion of the statements made by GLOBE students (p<.001, binomial test) were environmental inferences and explanations (77%, compared with 53% for the non-GLOBE students). In addition, the GLOBE students required proportionately fewer specific-level prompts (17%) than did the non-GLOBE students (27%). These preliminary results, illustrated in Figures 6.3 and 6.4, suggest that the GLOBE students need less contextual support to elicit environmental inferences than do non-GLOBE students.

GLOBE students not only generated more environmental inferences per unit of talk, a greater proportion of their inferences were coded as higher-level—77%, compared with 53% for the non-GLOBE students (p<.001, binomial test). The majority of inferences made by non-GLOBE students more closely resembled superficial descriptions of the environmental scene, whereas GLOBE students more often generated inferential statements linking their knowledge of ecology to the visual patterns in the scene. Additional analyses are planned to compare the inferences generated by GLOBE students with those produced by an expert in ecology.

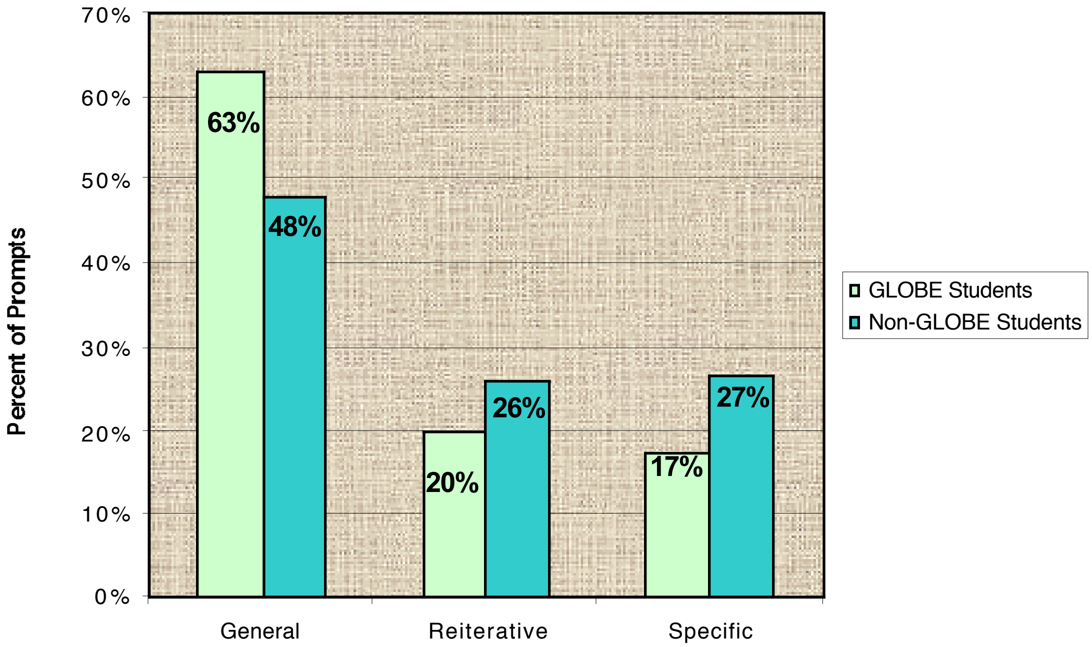
Figure 6.3
Proportion of Higher-Level Environmental Inferences



We believe that this pilot study provides preliminary evidence that GLOBE students in our sample had acquired sufficient background knowledge of environmental science to be able to recognize the significant visual elements and relate them to patterns present in ecological systems. Compared with non-GLOBE students, they were able to draw inferences by using the information that they had learned in GLOBE in ways that portrayed a more coherent Earth systems approach to understanding the environment. In other words, the GLOBE students exhibited a greater degree of environmental awareness than their peers.

We intend to develop this environmental awareness task further. To increase the reliability of our results, we will include additional GLOBE and non-GLOBE students, as well as experts in ecology, in our sample. We also intend to transfer this task into an interactive Web-based performance activity with an "automatic" scaffolded prompting system. It is our hope that further development of this task will allow us to explore ideas for enabling students to acquire greater understanding of Earth systems in explanatory and inferential forms.

Figure 6.4
Types of Prompts Given to GLOBE and Non-GLOBE Student Groups



Teacher Perceptions of What Students Learn

The final section of this chapter focuses on teachers' perception of what their students learn through GLOBE. When asked about the extent to which their students had improved in various types of skills through their GLOBE experiences, teachers overall reported the greatest gains in the areas of observational and measurement skills, ability to work in small groups, and technology skills. More than two-thirds of the GLOBE-implementing teachers in our survey sample reported that their students' observational skills had increased "very much," 56% said measurement skills had increased "very much," half reported a "very much" increased ability to work in small groups, and 40% reported a similar increase in students' technology skills (see Table 6.1).

Table 6.1
Teacher Reports of How Much Their Students' Skills Increased with GLOBE
(Percent Reporting)

Skill Area	*Very Much*	*Somewhat*	*Not Very Much*	*Not at All*
Observational skills	68	31	<1	<1
Measurement skills	56	42	1	<1
Ability to work in small groups	50	42	7	<1
Ability to understand data	44	45	9	3
Technology skills	40	45	12	4
Critical-thinking skills	34	50	13	3
Map skills	30	48	13	10
Ability to regulate own learning	21	47	24	9
English language skills	18	41	30	11
Other language skills	8	23	35	34

Sample sizes: $178 \leq n \leq 222$

Teachers vary in the degree to which they implement GLOBE, and we explored the relationship between the parts of GLOBE that teachers implemented and their perceptions of student learning. For this analysis, teachers who indicated that they had their students analyze, discuss, or interpret GLOBE data or engage in GLOBE learning activities were coded as "high implementers," and teachers who checked neither were coded as "low implementers." Table 6.2 contrasts the proportions of high and low implementers reporting that their students' skills increased very much in each of the skill areas on the survey. As can be seen in the table, those teachers who reported having their classes analyze and discuss the data or take part in learning activities perceived stronger positive effects on their students' learning. Although other interpretations are possible, this data pattern is certainly consistent with the hypothesis that teachers who put more into GLOBE in terms of a well-rounded implementation get more out of it in terms of student learning. The differences between high and low implementers were particularly striking in the areas of observation and measurement skills, ability to understand data, and ability to work in small groups.

Table 6.2
Teachers Reporting That Student Skills Increased "Very Much," by Implementation Level (Percent Reporting)

Skill Area	*High Implementers*	*Low Implementers*
Observational skills	75	47
Measurement skills	64	32
Technology skills	45	29
Ability to understand data	50	25
Ability to work in small groups	57	28
Critical-thinking skills	39	18
Map skills	33	17
Ability to regulate own learning	23	15
English language skills	21	4
Other language skills	10	0
Sample sizes:	$113 \leq n \leq 163$	$39 \leq n \leq 56$

Teachers who implemented GLOBE with students were also asked to rate the magnitude of GLOBE's impact on their students' knowledge in content areas, including both the GLOBE investigation areas and geography. Table 6.3 shows the teacher ratings. The largest perceived student knowledge gain was in knowledge about Atmosphere (69% thought their students' knowledge had increased "very much"), followed by GPS (41%) and Hydrology (36%). The next highest rating was given for Seasons, with 31% of teachers reporting that their students' knowledge had increased "very much."

More than two-thirds of the GLOBE teachers reported that their students' knowledge of geography had increased either "very much" or "somewhat." This is an intriguing finding, since geography is not explicitly taught in GLOBE. It is likely that teachers believe their students are acquiring knowledge of geography as a by-product of viewing

GLOBE visualizations or communicating with GLOBE participants in other parts of the world.

Table 6.3
Teacher Reports of How Much Student Content Knowledge Increased (Percent Reporting)

Knowledge Area	*Very Much*	*Somewhat*	*Not Very Much*	*Not at All*
Atmosphere	69	29	2	<1
GPS	41	30	15	14
Land Cover/Biology	23	34	21	22
Hydrology	36	39	7	18
Seasons	31	36	18	16
Geography	27	42	18	13
Soil	22	26	24	29

Sample sizes: $137 \leq n \leq 219$

A comparison of Table 6.3 with the protocol implementation tables in Chapter 4 shows a strong (and not surprising) relationship between the areas that GLOBE teachers report implementing and those where they perceive that their students experience the greatest knowledge increases. A second analysis removed the factor of differential implementation rates by examining the knowledge gains reported by only those teachers who had implemented each of the investigation areas with their students. (See Table 6.4.)

When we look only at responses of teachers who implemented the investigation being rated, the differences between Atmosphere and other investigation areas are greatly reduced. Even so, teachers still rated the knowledge gains in Atmosphere significantly higher than those in the other content areas, with 70% reporting that student knowledge increased “very much,” compared with 59% for Seasons, the second most highly rated knowledge gain. Teachers’ perceptions of student knowledge gains concerning the seasons is noteworthy because understanding seasonal changes involves integrating a complex set of interconnected ideas that cut across the other GLOBE investigation areas. These reports of perceived gains may reflect greater teacher emphasis and continuity of involvement with these two content areas, which are, in fact, prominent in many science curricula. When we look only at the responses of teachers who implemented a given investigation, as in Table 6.4, we find that the perceived knowledge gains are approximately equal for the Hydrology, GPS, and Soil investigations, in contrast to the data pattern in Table 6.3. Perceived knowledge gains in Land Cover/Biology are somewhat more modest.

Table 6.4
Teacher Reports of How Much Student Content Knowledge Increased for Investigation Areas They Implemented
(Percent Reporting)

Knowledge Area	*Very Much*	*Somewhat*	*Not Very Much*	*Not at All*
Atmosphere	70	29	1	<1
GPS	54	32	8	6
Land Cover/Biology	44	42	8	6
Hydrology	52	42	1	5
Seasons	59	24	10	7
Soil	53	29	9	9

Sample sizes: $41 \le n \le 212$

Conclusion

Taken together, the data in this chapter provide both formal and informal evidence suggesting that students are developing a deeper understanding (as reflected in their reasoning) of their global environment as a result of participating in the GLOBE program. GLOBE students of various ages have provided us with examples in which they grapple with difficult problems, are questioning the ideas presented to them, and are able to draw inferences in their search for answers to scientific questions. In addition, when asked explicitly, GLOBE teachers report that their students are learning concepts in environmental science. Moreover, our data suggest that students' personal involvement in taking measurements repeatedly, classroom implementation of learning activities, and data analysis and interpretation are significant factors in supporting students' learning.

Chapter 7. Scientists' Involvement with GLOBE

No group bears more responsibility for improving K-12 math and science education than the scientific community itself.

—*Rita Colwell, Director, National Science Foundation*

The rationale for developing student-scientist partnerships in science education programs is often expressed in terms of increasing student inquiry, eliciting student learning during authentic investigations, and promoting scientific careers and opportunities for those students who would not necessarily have entered scientific fields before. These programs usually focus their attention on the "student partner." Rarely do they inquire about the impact that such programs have on the scientists involved. Because the student-scientist relationship built into the GLOBE program is so unusual and because one of the three main goals of GLOBE is to increase scientific knowledge about Earth systems, we turned to the GLOBE scientists as data sources with respect to these issues. At the completion of their 3-year grants, all GLOBE II science principal investigators (PIs) were asked to respond to an on-line survey concerning: (1) the quality of GLOBE data in their investigation area, (2) their use of the data that students had been collecting, and (3) the ways in which they had interacted with GLOBE teachers and students. Eight out of nine GLOBE II science PIs responded.

Scientists' Role in GLOBE

The GLOBE program seeks to facilitate a collaboration between students, teachers, and scientists by involving them in authentic investigations about Earth systems. The science component in GLOBE is perceived to be critical for the success of the program. Its central purpose is to provide the scientific community with access to a useful database about the Earth. At the same time, the fact that GLOBE science investigations are real research adds an important level of authenticity to the hands-on experiences students have in GLOBE (thus enhancing the education component). To achieve these aims, there is an expectation that the scientists will exhibit a high level of commitment as they actively participate and support a major Internet-based international science and education program. Before presenting the results of the scientists' survey, we describe the history of scientist participation in order to put the survey responses in context.

Developing Investigations

Scientists' involvement in GLOBE began with a workshop in Aspen, Colorado, in September 1994. During that workshop, invited scientists and educators were faced with the challenge of identifying the minimum set of areas in which students would need to make measurements in order to advance both their own understanding of (1) the Earth as a dynamic system and (2) the scientific database about our globe. The three broad areas for scientific measurement that emerged from the workshop were atmosphere/climate, hydrology/water chemistry, and biology/geology.

Scientists also worked with the GLOBE program staff to identify reasonably low-cost equipment that students could use to conduct the measurements with an acceptable degree of accuracy and reliability. (Using state-of-the-art technology has proven to be a motivator for students' sustained involvement in the program.) Materials from existing environmental education programs were combed to identify educational activities related to the measurement protocols. Scientists participating in this formative phase of the program thus had a major voice in shaping the first edition of the GLOBE Teacher's Guide.

In November 1994, the National Science Foundation invited applications from teams of Earth scientists and educators interested in shaping the second phase of GLOBE investigations (GLOBE II). Interested scientists were required to form collaborations with science educators and to submit proposals. Proposals for designing scientific investigations were requested 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, as well as in the use of global positioning systems (GPS). Each team was headed by a scientist principal investigator (PI) committed to (1) using GLOBE data in his or her research and (2) 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 following year. During this time, the first draft of the substantially rewritten second edition of the Teacher's Guide became available for training teachers in the summer of 1996.

In 1997, scientists and educators involved in GLOBE II were asked to reconvene in order to develop a supplement to the second edition of the Teacher's Guide. Again, the scientists and educators were faced with the task of expanding the number of data collection protocols, modifying existing ones, and developing new learning materials and activities (see Chapter 1 for a review of new protocols and learning activities). All of their work resulted in a Teacher's Guide Supplement, which was published in August 1997. What is apparent is that scientists have been seriously involved in developing the GLOBE program from both scientific and curricular perspectives.

Scientists' Corner, Web Chats, and Classroom Visits

From its beginning, GLOBE has sought a way to connect students with GLOBE scientists without overburdening the participating PIs. The earliest attempt to provide students and teachers with a sense of personal connection to the scientists, as well as additional context for GLOBE investigations, was the Scientists' Corner section of the GLOBE Web site. This section contained rotating messages from individual scientists consisting of a personal statement about why the data collected by the students are important, as well as one or more digitized photographs of the scientists. The letter from the scientists for each investigation included in the second edition Teacher's Guide was another message transmitted to all schools by GLOBE scientists. Through the inclusion of photographs and personal details of the scientists' lives, these messages attempted to give students the feeling of partnership with specific individuals. GLOBEMail was a technology feature that could be used for communication and the exchange of ideas and questions between students and scientists. Several GLOBE scientists began GLOBEMail or regular electronic mail exchanges with some of the more active GLOBE classrooms.

Live "Web chats" with GLOBE scientists, teachers, and students were held in the second and third years of the program. Notices of upcoming Web chats were placed on the GLOBE Web site so that teachers and students would have time to prepare. These Web chats provided students with opportunities to ask questions of and offer explanations directly to GLOBE scientists. Transcripts of the on-line discussions were stored on the Web site so that others who had missed the live chats had the opportunity to benefit from reading the transcripts of the discussions. To date, more than a dozen separate Web chats involving scientists have occurred, and five additional ones are planned for the near future.

On some occasions, scientists have formed close relationships with those schools where teachers and students are submitting data in their investigation area. It is easy to see how students and teachers can benefit from the scientists' visits to their classrooms because they can ask the scientists questions, and visits help to build relationships. At the same time, class visits enable scientists to see how the investigations are being conducted, to acquire a better understanding of the inquiry needed to sustain students' learning, and to develop a more realistic understanding of the nature of schools.

Data Quality

Not suprisingly, an important concern for the GLOBE scientists is the quality of the data collected by students. When the scientists were asked to describe the analyses that they have conducted to evaluate the reliability and validity of the GLOBE data, almost all of the GLOBE scientists reported that they had visually inspected the data for errors, completeness of entries, and inconsistencies. One scientist reported that he had run pilot tests with several hundred students to determine whether data collected by students are of sufficient quality for scientific use. According to the scientist, the data are of sufficient quality for scientific use and have been used in an extensive pilot study with approximately 600 students at a study area in Pawtuckaway State Park in New Hampshire.

Although many of the scientists stated that the data were inconsistent or contained obvious outliers, most of their concerns were directed at the incompleteness of the data due to a lack of consistent and continuous reporting. The lack of sufficient data may have little to do with students' ability; rather, it is more likely related to the nature of school schedules and timetables, which often constrain students' and teachers' time, making it very difficult to collect data on a regular schedule on a continuous basis. Despite this finding, when asked to describe the quality of the data, three of the science PIs gave positive assessments (e.g., the data look promising, the data appear reliable, or the data quality is sufficient for scientific use). When GLOBE data have been compared with other data sets, there has always been a high level of agreement (Becker et al., 1998; Congalton & Becker, 1996; Lawless & Rock, 1998; Levine, 1998).

Data Use

Several of the scientists mentioned the use of the student database for their own research. Specifically, four of the eight scientists reported that they had used GLOBE data to conduct analyses other than those to check the quality of the data. Two scientists reported that they had used the data to validate their models or to compare their data with previously collected data. Three of the scientists had presented the results of such analyses at GLOBE-sponsored meetings, and two of the scientists had presented their work at national or international research conferences and had published their research using GLOBE data in professional journals (Becker et al., 1998; Congalton & Becker, 1996; Lawless & Rock, 1998; Levine, 1998).

The remaining scientists felt that it was too early in the data collection phase to begin using the student-supplied data for their research or to have others use these data for scientific purposes. However, many described future plans for research and collaboration. For instance, one scientist described a "plan to collaborate with EOS/MODIS investigations to use GLOBE students to provide ground site and processed image data to train and validate MODIS landcover map products." Another scientist stated that she will continue model validation with GLOBE data and hopes to conduct a study "relating phenology measurements from the bud burst investigation with soil temperature and morphological properties to predict the onset of the growing season." Finally, a third scientist stated that he would like to develop a "validation collaboration with the ASTER EOS [Earth Observing System] team on surface temperature."

Scientists' Recommendations

When asked what steps could be taken to strengthen GLOBE data, many of the scientists made specific suggestions about data collection. For example, scientists recommended that the GLOBE program (1) "get regular gravimetric observations in schools," and (2) take "long-term continuous measurements for soil temperature (throughout the whole soil profile), soil moisture and climate."

Still other scientists made recommendations related to strengthening GLOBE data by improving other aspects of the program (e.g., teacher training, GLOBE technology). Examples included "retro-fit earlier trained teachers for newer protocols" and "create consistent training of learning activities and protocols." Finally, another scientist related the strengthening of GLOBE data to particular features in the structure of the GLOBE database and the role of e-mail. In particular, he stated that it was "critical for schools to enter 'metadata' and for the system to make these 'metadata' easily accessible." Furthermore, he stated that we "need quick and efficient access to email communication with any or all of the GLOBE schools."

Conclusion: Progress toward Student-Scientist Partnerships

On our on-line survey, all of the scientists reported that they had exchanged electronic mail, visited GLOBE classrooms, and collaborated with teachers in developing training materials. Seven out of eight stated that they had prepared a Scientists' Corner message, participated in a Web chat, and collaborated with schools on either investigations, papers, or conference presentations. If we simply examine whether GLOBE is making progress toward the goal of expanding knowledge in scientific fields of study, it appears that progress to date has been limited (but many of the scientists see promise). If we examine GLOBE's progress with respect to the formation of student-scientist partnerships, on the other hand, it appears that all the scientists who have been involved in the GLOBE program have had increased interaction with teachers and students, and many are starting to participate in new learning communities involving schools.

When the scientists were asked whether their interactions in GLOBE had affected the way they view their field of study, five out of eight reported that this involvement had made a difference. One scientist claimed that "the act of explaining a complex field of soil science to young students has helped me to focus on relevant concepts and issues that are most important." Another stated that he "has a much richer appreciation for the diversity and variability of the natural environment." Finally, one scientist reported that it "heightened his awareness of the need for good spatial and temporal coverage of water quality data, and the possibilities of achieving this."

The word "partnership" implies that both parties derive real benefits. In science education programs, however, it is often easier to see the benefits for students than for scientists (Malcolm, 1997). The question of whether the GLOBE program will help scientists in their own research remains unanswered because the program is still in its early stages of development. However, the number of interactions that scientists have had with GLOBE teachers, students, and schools continues to grow and to offer a tremendous opportunity for new insights and new learning for all.

Chapter 8. Summary and Recommendations

After 3 years of collecting data on the GLOBE program's implementation in schools and classrooms, we can begin to take stock and reflect on the program's success vis-à-vis its central goals. GLOBE was launched as a science and education program with the goals of:

- *Helping all students reach higher levels of achievement in science and mathematics;*
- *Enhancing the environmental awareness of individuals throughout the world; and*
- *Contributing to scientific understanding of the Earth.*

Progress toward Program Goals

Science and Mathematics Achievement

Both observations of GLOBE students' activities, such as those described in Chapter 6 of this report, and structured assessments of student knowledge (i.e., the comparative study of GLOBE and non-GLOBE classrooms conducted in Year 2) suggest that in active GLOBE classrooms, the program has a positive impact on students' ability to collect and interpret scientific data. Nevertheless, as large as the GLOBE program is in terms of number of implementing teachers, it is still reaching only a fraction of any nation's classrooms and is far from the only science content taught there. Thus, it would be unrealistic to expect GLOBE to have significant impacts on a nation's or state's scores on standardized tests (even if the tests covered content similar to that involved in GLOBE) or that one could isolate GLOBE's effects on test scores from those of other variables.

The above discussion is intended to put GLOBE's student achievement goal in perspective but not to minimize the importance of GLOBE's current and potential contribution. The fact that GLOBE appears to influence teachers' approach to science in ways congruent with the national science standards and that there is a measurable positive impact on students' mathematics and science learning (see Means et al., 1997) means that the spread of the program and its influence is worthwhile. As will be suggested later in this chapter, GLOBE can add more value through well-established, long-term programs with data collection, learning activities, and data analysis and inquiry integrated into a coherent whole than through increasing the number of schools and teachers involved per se. The evolution of the program's education model, with the greater stress on having teams of teachers implementing GLOBE within a school site and on equipping local franchises to train and support GLOBE teachers, attempts to provide support for high-quality, sustainable programs.

Increasing Environmental Awareness

The evaluation team has been grappling with the issue of how to define and assess progress toward GLOBE's environmental awareness goal for some time. GLOBE students' responses on surveys administered in Years 1 and 2 suggested that they have a high awareness of the interdependence of events in different parts of the world and an interest in undertaking activities to improve their local environments. However, the survey responses of non-GLOBE students (whose teachers had signed up for but not yet taken GLOBE training) in our Year 2 comparative study showed that these students have similar attitudes.

In Year 3, we decided to address the issue of environmental awareness from a science knowledge perspective, going beyond expressions of positive attitudes to explore students' scientific awareness of the environment—the extent to which GLOBE has given them a more differentiated, deeper understanding of the natural world. Our pilot findings, reported in Chapter 6, are positive. GLOBE students appear to make more science-based, higher-level environmental inferences than their non-GLOBE peers. In Year 4, we will administer more structured assessments of environmental awareness to larger samples of GLOBE and non-GLOBE students.

Contributions to Scientific Knowledge

Over time, GLOBE's contribution to science will be apparent from the number of scientists using the database, the number of analyses using GLOBE data appearing in peer-reviewed journals, and the areas of the world and scientific variables for which GLOBE provides unique data sets. It takes considerable time, of course, not only to accumulate useful data sets but also to perform and interpret analyses, prepare reports, and get them published. The responses of the GLOBE II science principal investigators (PIs) suggest that it is too soon to judge whether GLOBE will make significant contributions to the scientific knowledge base. PIs have all done at least preliminary analyses of the quality of the data in their investigation areas. Their analyses suggest that there are some common errors (e.g., failure to reset indicators on the maximum/minimum thermometer)—and the program has been taking steps to identify such errors and reduce their likelihood through modifications to reporting forms, additional automated data checks at time of input, and refinements of protocols and calibration and conversion procedures. Moreover, several analyses relating GLOBE student data to data sets from other sources suggest a high degree of agreement (Becker et al., 1998; Congalton & Becker, 1996; Lawless & Rock, 1998; Levine, 1998), giving credibility to the student data. GLOBE science PIs are hoping to see an increase in the number of long-term, complete data sets in their areas of study.

Although the jury is still out concerning GLOBE’s contribution to Earth science data sets, our PI survey results suggest that the program may have secondary benefits for the scientists involved. Five of the eight PIs noted that their interactions with students had pushed them to look at their fields of study in a new, more integrative way. As they seek to help students put the individual investigations into an Earth systems context, PIs too may evolve toward more interdisciplinary perspectives.

Quality of Implementation: The Key to Further Improvements

It seems clear that GLOBE’s ability to make further progress on both its educational and its scientific goals will hinge on the quality of the supports provided for local program implementation. Many teachers finishing their initial GLOBE training have characterized the program in its entirety as an overwhelming undertaking. The program is struggling with ways to keep the requirements placed on teachers at a reasonable level as the number of data collection protocols has been increasing.

First and foremost among the strategies for making GLOBE easier to manage is the multiple-teacher or “community of learners” implementation model. Teachers who can work with colleagues to implement GLOBE don’t feel that they have to be expert in every aspect of the program. Moreover, the time required for implementing the program then does not all have to come out of a single class or club period. A number of international and franchise partners are requiring that schools send teacher teams, rather than individual teachers, for training.

A more manageable training schedule is another effort to make it easier to begin implementing GLOBE. In summer 1998, the decision was made to designate a subset of GLOBE protocols as "basic." Starting in the spring of 1999, the first three days of contract training will concentrate on just these basic protocols plus supporting learning activities. A fourth, optional day can be spent either reviewing the basic protocols or receiving training on additional protocols, at the teacher's option. Previously trained teachers are encouraged to attend the fourth day to learn about protocols that were not in place at the time they were trained or to brush up on protocols they were trained on but have not implemented.

Issues for Continued Program Refinement

A major strength of the GLOBE program is its willingness to examine its own practices and make refinements to improve the program. Each year, the evaluation team has identified a set of issues for the program's attention. After 3 years of operation, we see six interrelated challenges facing the GLOBE program as it moves forward.

Increasing the Number of Types of Data Reported by Individual Sites

Nearly all GLOBE schools are implementing some portion of the Atmosphere investigation. Atmosphere is appealing to teachers both because it relates to weather concepts that are part of many curricula and because the instrumentation for the protocols is relatively inexpensive and straightforward to use (see Chapter 4). A fuller picture of the Earth requires consideration of the land and water as well as air, however. Experience with the program to date suggests that the training and supports for other investigation areas need to be very strong and that the concepts and protocols need to be clarified for teachers with limited science backgrounds. The Teacher's Guide materials and training content appear to be improving in these regards, but the program may want to consider asking an advisory panel of science education experts to review existing materials and make recommendations for the next round of revisions.

In addition to efforts to make the materials more appealing (or less intimidating), refresher training strategies, such as those implemented by a number of GLOBE franchise and international partners, can help promote fuller implementation. The new model for contract training with an option for previously trained teachers to take the fourth day of training on advanced protocols should help address this issue.

Obtaining More Consistent, Continuous Data Sets

If GLOBE is to fulfill its science objective, there need to be more sites adhering to a consistent data collection protocol over the long term. Sharing strategies for collecting data on weekends and during school breaks and other interruptions is one effort in this direction. But dissemination of such strategies will do little good unless there are individuals with a strong motivation to use them. GLOBE is seeking strategies to increase the number of schools with this level of commitment. Stronger support for and greater interaction with local GLOBE franchises and increased communication with scientists are being explored as strategies for addressing this concern.

A major part of the education reform movement is based on the premise that if clear, demanding standards are set, school performance will improve. The GLOBE program might try a similar strategy with its data collection protocols. If the scientists for a particular investigation were to articulate standards for an adequate data set and to reinforce the standards with ongoing messages to (and perhaps concrete incentives for) schools that are nearing the standard (as well as communication with those that appear to be falling away from standards), teachers might well feel a heightened sense of commitment and obligation to the program.

Dealing with Teacher Turnover

National statistics (National Center for Education Statistics, 1997) indicate that at the end of each school year, approximately 13% of teachers will leave the school at which they have been teaching (either to move to another school or to leave the profession).

GLOBE teachers are not immune to this national trend. Several of the most active GLOBE teachers highlighted in our case studies during the program's first two years, for example, are no longer in teaching positions. Recognition of this fact of school life was one of the motivations behind the program's recommendation that multiple teachers be trained from each school. Nevertheless, we know that there are many schools with only a single trained teacher and that when that teacher leaves, the GLOBE program may either cease to exist or be turned over to a teacher with no formal GLOBE training. Mechanisms need to be in place to "recapture" GLOBE schools that have lost their trained teacher. The GLOBE Help Desk could play a role by monitoring previously active schools each fall and checking in with those that do not start reporting data.

Maintaining the Quality of Teacher Training and Teacher Implementation

As more and more teachers receive GLOBE training, the maintenance of quality control will gain in importance. A teacher certification test measuring mastery of the protocols is not a desirable option because it would be likely to discourage many teachers from participating. Taking a "carrot" rather than a "stick" approach, GLOBE franchises could consider identifying GLOBE "master teachers," who would be given a stipend for providing technical assistance, feedback, and coaching for other GLOBE teachers, either in person or over an electronic network. Mentor teachers could arrange visits to GLOBE schools in their local areas and could teach demonstration "lessons" or team teach with the school's GLOBE teachers. Such support would be particularly helpful as GLOBE teachers try out investigations that are new to them. It is recognized that master teachers could not be expected to undertake such mentoring in their "spare" time, and the identification of (non-GLOBE) funds to release them from part or all of their regular teaching load would need to be part of the strategy. Increasing the amount of ongoing contact with scientists (see discussion below) is another mechanism likely to improve the scientific integrity of the data collected and reported. Additional strategies for improving teacher implementation could be revealed through empirical analyses of the data contributions for schools trained by franchises with varying training models.

Improving Content Integration

Although the GLOBE materials have improved considerably from the first Teacher's Guide in terms of the amount of cross-referencing across investigation areas, the materials are still not as well integrated conceptually as one would like. It is expected that the revisions and new materials to be developed by the new set of GLOBE grantees selected in 1998 will shore up this aspect of the program. Asking a panel of science education advisors to address this issue specifically (to consider, for example, whether the rock cycle needs to be addressed to provide an adequately complete view of Earth systems) could further improve the program.

Measuring GLOBE materials by the standards advocated in U.S. national standards documents such as *Benchmarks for Science Literacy* (see American Association for the Advancement of Science, 1993) and *National Science Education Standards* (National Research Council, 1996) and against internationally accepted frameworks such as that used in generating the Third International Mathematics and Science Survey (Schmidt, McKnight, & Raizen, 1997), we would give GLOBE very high marks for involving students in authentic science inquiry and for integrating science and mathematics. The materials fare less well in terms of articulating a small set of powerful "big ideas" (such as cycles, adaptation, and interdependence) that help explain scientific phenomena in a range of fields (see American Association for the Advancement of Science, 1993).

The use of "big ideas" to integrate concepts across investigation areas and traditional academic departmental boundaries is one of GLOBE's greatest potential contributions. Although both mathematics and science education commissions are calling for such integration (American Association for the Advancement of Science, 1993; National Council of Teachers of Mathematics, 1991), high-quality programs with these characteristics are the exception rather than the rule. At the same time, it should be recognized that, as an integrated program, GLOBE is difficult to fit into the confines of traditional secondary school courses such as algebra, biology, or chemistry. Such courses can be a springboard for launching GLOBE clubs and may incorporate pieces of GLOBE, but they are unlikely to devote enough time within the course proper for a year-long implementation of GLOBE, especially given the press of tightly packed curricula linked to high-stakes tests (e.g., Advanced Placement examinations). GLOBE is much more easily implemented within general elementary classrooms and general or environmental/Earth science courses.

Increasing Personal Interactions with the Scientific Community

In Chapter 7, we described the progress that has been made in building active collaborations between the GLOBE science PIs and many GLOBE classrooms. We believe that data continuity and quality issues could be ameliorated with a further increase in the amount of personal involvement and communication, not only with the science PIs themselves but also with others working within their laboratories (e.g., graduate students) and in their spheres of influence.

A recent innovative approach to such interactions has been undertaken by the GLOBE Soil investigation team. Soil PI Elissa Levine has promised a sample of Bolivian soil from the site of a possible meteor impact to schools that have completed the Soil Characterization protocol. GLOBE students will be able to test their samples of Bolivian soil and compare them with their local samples. In addition, GLOBE students will be able to view a live video transmission of the scientists' collection of soil samples in Bolivia. In this way, GLOBE students can derive a greater degree of involvement with the science investigator, schools are given an incentive for completing a challenging protocol, and additional activities at the school site are supported.

Program Strengths

The above discussion of areas for improvement should not detract from the broad view of the GLOBE program's strengths. Students at thousands of schools are participating in real scientific investigations. Although the program is extremely challenging for teachers to implement, it is also viewed as extremely rewarding by its participants:

> *GLOBE is the best curriculum I have seen in 13 years of being an educator. My students love the hands-on approach. What they do now has more meaning to them [than other science materials], therefore enabling new skills and concepts to*

"stick" rather than never [be] used again. We have enjoyed the Web chats and the exchange with GLOBE schools around the world. The cross-curricular and inter-cultural experiences will be remembered for a lifetime. The "personal approach" from the scientists and GLOBE personnel . . . have all made our first year in GLOBE very pleasant and meaningful.

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APPENDIX:

1998 GLOBE Teacher Survey

GLOBE Teacher Survey

Name: ________________________________ Today's Date __________
(month/day/year)

Part A

A.1 When and where did you receive your GLOBE training?

____________ ________ ______________________
Month Year Location

A.2 Were you involved with the GLOBE program in school year 1997-98?

❐ Yes ➔ In what ways were you involved?

____

____

____

❐ No ➔ *Please skip to question A.4.*

A.3 Did you implement GLOBE activities with students during school year 1997-98?

❐ Yes ➔ *Please skip to Part B of this survey on page 3.*

❐ No ➔ *Please continue with question A.4.*

A.4 What barriers kept you from implementing GLOBE with students in 1997-98?

(Circle one number for each barrier.)

		Not a barrier	Minor barrier	Major barrier
a.	Difficulty finding time to *prepare* for implementing GLOBE.	1	2	3
b.	Lack of Internet access.	1	2	3
c.	Lack of computer hardware/software.	1	2	3
d.	Lack of technical support for using computers and software.	1	2	3
e.	Difficulty integrating GLOBE into existing curriculum.	1	2	3
f.	Difficulty finding time for GLOBE activities, given other curriculum and testing requirements.	1	2	3
g.	Difficulty identifying an appropriate site for taking GLOBE measurements.	1	2	3
h.	Concern about whether GLOBE would be valuable for your students.	1	2	3
i.	Difficulty completing GLOBE activities within the school schedule.	1	2	3
j.	Lack of a good way to collect GLOBE data on weekends, vacations, etc.	1	2	3
k.	Other. *Please describe:* ________________________________	1	2	3

A.5 Do you have plans to implement GLOBE activities with students at a future time?

❒ Yes ➔ *Please continue with question A.6*

❒ No ➔ *Please skip to question A.7*

A.6 Which GLOBE activities do you plan to implement?
(Circle one number for each activity.)

		Definitely plan to implement	Might implement	Definitely will NOT implement
a.	Take GLOBE measurements.	1	2	3
b.	Enter GLOBE data on the computer.	1	2	3
c.	Explore information on GLOBE Web site.	1	2	3
d.	Analyze, discuss, or interpret GLOBE data.	1	2	3
e.	Telecommunicate with other GLOBE schools.	1	2	3
f.	Engage in GLOBE learning activities.	1	2	3

A.7 What kinds of support from the GLOBE program would increase the likelihood that you would start implementing GLOBE? *(Circle one number for each support.)*

		No difference	Help somewhat	Big help
a.	Contact with scientists on how to conduct protocols.	1	2	3
b.	Contact with GLOBE teachers in my area.	1	2	3
c.	Contact and coaching from a GLOBE trainer in my area.	1	2	3
d.	Help in obtaining computer equipment.	1	2	3
e.	Help in obtaining an Internet connection.	1	2	3
f.	A phone call from a computer technician from the GLOBE Help Desk.	1	2	3
g.	Additional or refresher training through the World Wide Web.	1	2	3
h.	Additional face-to-face training.	1	2	3
i.	Videotapes on how to conduct GLOBE protocols.	1	2	3
j.	Funding for GLOBE equipment.	1	2	3
k.	Other. *Please describe:* ______________________________	1	2	3

Thank you very much for your help in completing this survey. If you have any further comments, you may use the space on page 13. Please use the enclosed business reply envelope to return the survey to:

GLOBE Evaluation
SRI International
Room BS 121
333 Ravenswood Avenue
Menlo Park, CA 94025 USA

Part B

GLOBE IMPLEMENTATION AT YOUR SCHOOL

B.1 Which GLOBE activities did you implement with students in 1997-98? *(Circle all that apply.)*

1	Take GLOBE measurements.
2	Enter GLOBE data on the computer.
3	Explore information on GLOBE Web site.
4	Analyze, discuss, or interpret GLOBE data.
5	Telecommunicate with other GLOBE schools.
6	Engage in GLOBE learning activities.
7	All of these. ➔ *(Please skip to question B.5.)*

B.2 For those activities you did *not* implement, which of the following were barriers?
(Circle one number for each barrier.)

		Not a barrier	Minor barrier	Major barrier
a.	Difficulty finding time to *prepare* for implementing GLOBE.	1	2	3
b.	Lack of Internet access.	1	2	3
c.	Lack of computer hardware/software.	1	2	3
d.	Lack of technical support for using computers and software.	1	2	3
e.	Difficulties integrating GLOBE into existing curriculum.	1	2	3
f.	Difficulty finding time for GLOBE activities, given other curriculum and testing requirements.	1	2	3
g.	Difficulty identifying an appropriate site for taking GLOBE measurements.	1	2	3
h.	Concern about whether GLOBE would be valuable for your students.	1	2	3
i.	Difficulty completing GLOBE activities within the school schedule.	1	2	3
j.	Lack of a good way to collect GLOBE data on weekends, vacations, etc.	1	2	3
k.	Other. *Please describe:* ______________________________	1	2	3

B.3 Which GLOBE activities do you plan to implement at a future time?
(Circle one number for each activity.)

		N/A (Have already implemented)	Definitely plan to implement	Might implement	Definitely will NOT implement
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
g.	Other. *Please describe*: ________________________	1	2	3	4

B.4 What kinds of support would increase the likelihood that you would start implementing additional GLOBE activities? ***(Circle one number for each support.)***

		No difference	Help somewhat	Big help
a.	Contact with scientists on how to conduct protocols.	1	2	3
b.	Contact with GLOBE teachers in my area.	1	2	3
c.	Contact and coaching from a GLOBE trainer in my area.	1	2	3
d.	Help in obtaining computer equipment.	1	2	3
e.	Help in obtaining an Internet connection.	1	2	3
f.	A phone call from a computer technician from the GLOBE Help Desk.	1	2	3
g.	Additional or refresher training through the World Wide Web.	1	2	3
h.	Having another GLOBE-trained teacher to help implement the program at my school.	1	2	3
i.	Videotapes on how to conduct GLOBE protocols.	1	2	3
j.	Other. *Please describe*: ________________________	1	2	3

B.5 During which years have you and your school implemented GLOBE activities with students?
(Circle all that apply in each column.)

		School implemented	You implemented
Spring	1995	1	1
School year	1995-96	2	2
School year	1996-97	3	3
School year	1997-98	4	4

B.6 Are there some kinds of GLOBE data you collected and reported for a while and then stopped reporting?

❒ No

❒ Yes ➔ Why did you stop collecting or reporting these data?

____

____

B.7 How many teachers (including yourself) at your school implemented GLOBE activities with students in 1997-98?

Number of teachers: ________

GLOBE CLASSROOM ACTIVITIES

B.8 Think about the *single class* or other setting in which *you* do the most GLOBE-related work with students. Show how many students at each grade level participate in GLOBE within this *single* class or other setting and how many participate in your entire school (including your other classes).

	Number of GLOBE students			Number of GLOBE students	
Grade level	*My most active class*	*Whole school*	Grade level	*My most active class*	*Whole school*
K	________	________	7	________	________
1	________	________	8	________	________
2	________	________	9	________	________
3	________	________	10	________	________
4	________	________	11	________	________
5	________	________	12	________	________
6	________	________			

B.9 Think again about the *single class* or other setting in which *you* do the most GLOBE-related work. How would you characterize this class or other setting? *(Circle one number in the appropriate column.)*

Elementary	**Middle/Secondary**
1 Comprehensive elementary class	5 Regular middle or secondary class Class title: ____________________
2 Elementary science class taught by science resource teacher	6 Pull-out program (students taken out of regular class for this activity)
3 Elementary lunch, club, or after-school interest group	7 Secondary lunch, club, or after-school interest group
4 Other elementary: ____________________	

B.10 During a typical week, how do you organize your students for GLOBE activities in this class or club? ***(Circle one number for each activity.)***

		Single student does it	Small group does It	Multiple small groups do it in parallel	Whole class does it together	N/A We don't do this activity
a.	Take GLOBE measurements.	1	2	3	4	5
b.	Enter GLOBE data on the computer.	1	2	3	4	5
c.	Use GLOBEMail or other features of the GLOBE Web site.	1	2	3	4	5
d.	Analyze, discuss, or interpret GLOBE data.	1	2	3	4	5
e.	Engage in GLOBE learning activities.	1	2	3	4	5

B.11 In a typical week, how many hours do you spend:

a. Working with students in your single most active class or club on GLOBE activities?

Number of hours: _________

b. Planning or preparing for these GLOBE activities?

Number of hours: _________

B.12 During school year 1997-98, how many weeks will students in your single most active class or club participate in GLOBE activities?

Number of weeks: _________

B.13 Think about the computers you use for GLOBE. Where are these computers located, and how many do you use for GLOBE in each location? ***(Enter a number for each location; enter 0 where applicable.)***

		Number used for GLOBE
1.	Your regular classroom	_______
2.	Computer laboratory	_______
3.	Library or media center	_______
4.	Other *(please specify)*: ______________________	_______

B.14 How often do you or your students use 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 month	Average of 1-3 times a month	Average of once a week or more
a.	Data entry	1	2	3	4	5
b.	Visualizations of student data	1	2	3	4	5
c.	Visualizations of reference data	1	2	3	4	5
d.	GLOBEMail	1	2	3	4	5
e.	GLOBE Student Data Archive	1	2	3	4	5
f.	Scientist Corner	1	2	3	4	5
g.	Frequently Asked Questions	1	2	3	4	5
h.	WebChats	1	2	3	4	5

B.15 Which GLOBE protocols are you implementing or planning to implement with your students?
(Circle one number on the scale for each protocol.)

Scale:	***Have already implemented***	***Definitely plan to implement***	***Might implement***	***Definitely will NOT implement***
	1	***2***	***3***	***4***

A. Atmosphere Protocols						**B. Hydrology Protocols**					
a.	Cloud Type	1	2	3	4	a.	Water Temperature	1	2	3	4
b.	Cloud Cover	1	2	3	4	b.	Dissolved Oxygen	1	2	3	4
c.	Rainfall	1	2	3	4	c.	pH	1	2	3	4
d.	Precipitation pH	1	2	3	4	d.	Alkalinity	1	2	3	4
e.	Solid Precipitation	1	2	3	4	e.	Electrical Conductivity	1	2	3	4
f.	Max/Min and Current Temperatures	1	2	3	4	f.	Water Transparency	1	2	3	4
						g.	Salinity	1	2	3	4
						h.	Salinity Titration	1	2	3	4
						i.	Nitrate	1	2	3	4

B.15 (Continued.) Which GLOBE protocols are you implementing or planning to implement with your students? ***(Circle one number on the scale for each protocol.)***

Scale:	*Have already implemented* **1**	*Definitely plan to implement* **2**	*Might implement* **3**	*Definitely will NOT implement* **4**

C. Land Cover/Biology Protocols				
a. Qualitative Land Cover	1	2	3	4
b. Quantitative Land Cover (forest, woodland, or grass land)	1	2	3	4
c. Land Cover Mapping (manual or unsupervised)	1	2	3	4
d. Accuracy Assessment	1	2	3	4

D. Soil Protocols				
a. Soil Characterization Field Measurements	1	2	3	4
b. Soil Characterization Lab Analysis	1	2	3	4
c. Gravimetric Soil Moisture	1	2	3	4
d. Gypsum Blocks Protocol	1	2	3	4
e. Infiltration	1	2	3	4
f. Soil Temperature	1	2	3	4

E. GPS Protocols				
a. GPS Measurement	1	2	3	4
b. Offset GPS	1	2	3	4

B.16 What are the *three* most important factors leading you to implement the protocols you do and not others?

(1) ____

(2) ____

(3) ____

B.17 Which GLOBE learning activities are you implementing or planning to implement with your students? *(Circle one number on the scale for each learning activity.)*

Scale:	*Have already implemented*	*Definitely plan to implement*	*Might implement*	*Definitely will NOT implement*
	1	*2*	*3*	*4*

A. Atmosphere Learning Activities						**B. Hydrology Learning Activities**					
a.	Observing, Describing, and Identifying Clouds	1	2	3	4	a.	Water Walk	1	2	3	4
b.	Estimating Cloud Cover: A Simulation	1	2	3	4	b.	Model Your Watershed	1	2	3	4
c.	Studying the Instrument Shelter	1	2	3	4	c.	Practicing the Protocols	1	2	3	4
d.	Precipitation: Location Bias in Measurement	1	2	3	4	d.	The pH Game	1	2	3	4
e.	Building a Thermometer	1	2	3	4	e.	What Can Live Here?	1	2	3	4
f.	Land, Water, and Air	1	2	3	4	f.	Further Investigations	1	2	3	4
g.	Cloud Watch	1	2	3	4	g.	Water Detectives	1	2	3	4
						h.	Water, Water Everywhere!	1	2	3	4

C. Land Cover/Biometry Learning Activities						**D. Soil Learning Activities**					
a.	Odyssey of the Eyes	1	2	3	4	a.	Soil and My Backyard	1	2	3	4
b.	Some Like It Hot	1	2	3	4	b.	A Field View of Soil—Digging Around	1	2	3	4
c.	Discovery Area	1	2	3	4	c.	The Data Game	1	2	3	4
d.	Site Seeing	1	2	3	4	d.	How Much Water Does Soil Hold?	1	2	3	4
e.	Seasonal Changes in Your Biometry Site	1	2	3	4	e.	Soil: The Great Decomposer	1	2	3	4
f.	Bird Classification	1	2	3	4	f.	Just Passing Through	1	2	3	4
g.	What's the Difference?	1	2	3	4	g.	Making Sense of the Particle Size Distribution	1	2	3	4
h.	Leaf Classification	1	2	3	4						

B.17 (Continued.) Which GLOBE learning activities are you implementing or planning to implement with your students? ***(Circle one number on the scale for each learning activity.)***

Scale:	*Have already implemented*	*Definitely plan to implement*	*Might implement*	*Definitely will NOT implement*
	1	*2*	*3*	*4*

E. GPS Learning Activities					**F. Seasons Learning Activities**				
a. Relative and Absolute Directions	1	2	3	4	a. Observing Seasonal Changes in the Local Study Sites	1	2	3	4
b. Working with Angles	1	2	3	4	b. Students Ask Questions About the Seasons	1	2	3	4
c. Offset GPS Measurements	1	2	3	4	c. What Should Your Students Investigate?	1	2	3	4
d. What Is the Right Answer?	1	2	3	4	d. Using Graphs to Explore Annual Temperature Cycles	1	2	3	4
e. Celestial Navigation	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
					g. What Are Some Factors That Affect Seasonal Patterns?	1	2	3	4

B.18 What are the *three* most important factors leading you to implement the learning activities you do and not others?

(1) ____

(2) ____

(3) ____

GLOBE'S IMPACT ON STUDENTS

B.19 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.	Other language skills	1	2	3	4	9
j.	Ability to regulate their own learning	1	2	3	4	9

B.20 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.	Seasonal cycles	1	2	3	4	9
g.	Geography	1	2	3	4	9

GLOBE TEACHER TRAINING AND SUPPORT

B.21 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 number 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 Learning Activities	1	2	3	4	b. Soil Learning 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 Learning Activities	1	2	3	4	b. GPS Learning Activities	1	2	3	4
C. Land Cover/Biology Investigation					**F. Seasons Investigation**				
a. Land Cover/Biology Protocols	1	2	3	4	a. Seasons Learning Activities	1	2	3	4
b. Land Cover/Biology Learning Activities	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					
d. Use of MultiSpec	1	2	3	4					

B.22 Have you provided GLOBE training for other teachers?

❐ No

❐ Yes ➔ If yes, in what settings? *(Circle all that apply.)*

1 At my school
2 Training workshop organized by GLOBE staff
3 At a GLOBE "franchise" training
4 Other *(specify)*:

____

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

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

Please use the enclosed business reply envelope to return the survey to:

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