GLOBE YEAR 5 EVALUATION

Classroom Practices

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Executive Summary

Global Learning and Observations to Benefit the Environment (GLOBE) is an international environmental science research and education program. Through GLOBE, K-12 students are involved in authentic science investigations, led by GLOBE scientists who have designed the data collection protocols and who review and analyze the student data. Using the World Wide Web, GLOBE students report the measurements they have taken at their local study site to the Student Data Archive, which serves as a resource for both GLOBE scientists and students. Since GLOBE began in 1995, GLOBE students have entered millions of measurements into this archive and reviewed the resulting patterns and trends using tables, map visualizations, and graphing tools.

The GLOBE Program (2001) has 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.

The GLOBE Program provides a set of data collection protocols 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. GLOBE provides a scientific framework and educational resources; but it is not intended to be either a curriculum or a fully specified educational intervention.

In addition to specifications for the measurement protocols, the GLOBE Teacher's Guide contains related learning activities for classroom use. 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 Evaluation

SRI International has provided evaluation services for the GLOBE Program since 1995. For the past two years, SRI's evaluations have focused on providing data to help this international science and education program refine its partnership approach to teacher training and support. In the Year 5 evaluation, we have taken a closer look at the classroom adaptations of GLOBE, examining ways in which teachers have adapted elements of GLOBE to their particular classrooms and priorities as well as the institutional supports that facilitate sustained program participation.

To obtain a broad picture of how GLOBE is used in classrooms, we distributed surveys to 1,700 GLOBE teachers. This represents the largest survey effort in the program's five-year history. Our survey samples were comprised of 1,000 U.S. teachers who were recently trained, and 500 U.S. and 200 non-U.S. teachers whose schools regularly submit at least four types of data to the GLOBE Web site.

In addition to survey data on GLOBE classroom activities and instruction, we also sought more detailed information by conducting case studies. These studies focused on five GLOBE classrooms in different regions of the United States. Each classroom had demonstrated high use of GLOBE and incorporated elements of student inquiry and investigation into their GLOBE activities.

Finally, we assessed students' environmental awareness and their skills in scientific data analysis within both GLOBE and non-GLOBE classrooms. As part of this analysis, we also examined how variations in classroom activities are associated with the data-reporting aspects of the program.

The Findings

Teacher Survey Responses

Surveys were received from over 1,000 GLOBE teachers: 512 of the recently trained teachers, 390 active U.S. teachers, and 131 active international teachers. Initial survey questions addressed the perceived influence of GLOBE training:

- Nearly all respondents (97% of recently trained teachers and 99.5% of active teachers) felt that going through GLOBE training had had some influence on their practice.

- The greatest influence of GLOBE training on teachers' science instruction appears to be an increased emphasis on incorporating observations and measurements into classroom science activities.

- Other strong influences were incorporation of more hands-on science activities and increased emphasis on data analysis.

The kinds of changes in pedagogy cited by teachers who completed GLOBE training are consistent with the science education teaching standards (NRC, 1996) and inquiry-oriented science instruction (NRC, 2000) as advocated by the National Research Council. Among active GLOBE teachers, the use of GLOBE-related explanations and examples and the introduction of new curriculum topics based on GLOBE were commonly cited as well.

While the active teacher sample was drawn from schools submitting data to the GLOBE archive on a frequent basis (and therefore, known to be implementing GLOBE), the recently trained teacher sample included teachers who had taken the training but not implemented the program with students as well as those who had implemented GLOBE.

Of the recently trained (between June 1998 and August 1999) teachers, 57% said they were "involved" with GLOBE in school year 1999-2000, and 50% said that they were actually implementing some aspect of GLOBE with students. Other forms of involvement cited by recently trained teachers not using GLOBE with students included participation in training, supporting other teachers, engaging in Web chat, and keeping up with GLOBE news. The major reasons cited for not implementing GLOBE with students included difficulty finding time to prepare (cited by 52% of nonimplementers), inability to find a way to collect data on weekends (47%), expected difficulty completing GLOBE activities within the school's schedule (44%), and concern about taking time away from mandated material (43%).

Among those teachers who did implement GLOBE with students in 1999-2000, the contexts within which the program is used vary between the United States and other GLOBE countries. In the United States, it appears that roughly half of GLOBE implementations are done at the elementary (K-5) level. Most GLOBE implementations are done as part of a regular class; less than a quarter involve a club, lunch-time activity, or "pull-out" program. Internationally, nearly three-quarters of GLOBE implementations are at the middle or high school levels and almost half of GLOBE programs are club, lunch-time, or pull-out activities.

Implementation contexts also vary in terms of whether a teacher is working alone to implement GLOBE or working as part of a school team. Among active GLOBE teachers, those from countries outside the United States are more likely than those in U.S. schools to have one or more GLOBE-trained teacher colleagues at their school (54% v. 44%). Active international teachers are almost twice as likely as their U.S. counterparts to be in a group of three or more teachers (22% v. 12%). This disparity between United States and international schools may decrease over time, however. Teachers drawn from the population of recent GLOBE U.S. trainees were notably more likely than teachers in the active U.S. school sample to have one or more GLOBE-trained teacher colleagues (60% v. 44%) at their school. Recently trained U.S. teachers were also more than twice as likely as active U.S. teachers to be in a group of three or more trained GLOBE teachers at their school (29% v. 12%).

On average, active teachers reported implementing GLOBE for 27 weeks—the great majority of an academic year. In contrast, recently trained teachers said they spent an average of 16 weeks implementing GLOBE with students. Active teachers reported spending on average 2.2 hours per week working on GLOBE with students in their single most active class. With an average program duration of 27 weeks, this constitutes giving their students 59 hours of exposure to GLOBE each year. Recently trained teachers who were implementing GLOBE with students reported spending an average of 2.0 hours per week on implementation, just slightly less time than active teachers. With an average implementation duration of 16 weeks, it appears that typical recently trained teachers implementing GLOBE in 1999-2000 provided their students with 32 hours of exposure to the program.

The survey asked teachers to indicate which particular aspects of GLOBE they had implemented with their students. Virtually all of the active teachers reported having their students take measurements (97%), and almost as many active teachers reported involving their students in submitting data (94%). Recently trained teachers who are implementing GLOBE with students are highly likely to have their students collect data (82%) but much less likely to involve students in submitting data to the Student Data Archive (44%). One possible reason for the difference in data reporting rates for the two survey samples is that, relative to their more experienced counterparts in the active-teacher sample, teachers trained in 1999-2000 favor using elements of the GLOBE Program more for the purposes of teaching and learning than for the purpose of contributing to the GLOBE database. This interpretation is compatible with teacher reports showing that recently trained teachers implement GLOBE learning activities at as high a rate as active teachers (both 75%).

Teachers were asked to respond to a survey item listing possible reasons that their school did not report data that their students had collected. The most widely cited reason for not submitting data that their students had collected is lack of time to complete the data submission. The second most commonly cited reason is lack of confidence in the quality of the data. The third biggest barrier reported is lack of access to a working Internet connection.

An examination of reported data collection activities by investigation area shows that the Atmosphere investigation remains the most commonly implemented, followed by Hydrology, and then Land Cover/Biology, and Soil (which have similar implementation rates). With the exception of Atmosphere, middle/secondary schools have higher implementation rates than elementary schools.

Most of the Atmosphere protocols were implemented by the overwhelming majority of active GLOBE teachers and by half or more of the recently trained teachers implementing GLOBE with students. In Hydrology, the most commonly implemented protocols at both the elementary and secondary levels were Water Temperature and Water pH, used in close to 40% of elementary GLOBE schools and approximately 60% of the secondary schools. Hydrology protocols were implemented at approximately equal rates by recently trained and active teachers. The most commonly implemented protocols in the Land Cover/Biology investigation area were Qualitative Land Cover, Quantitative Land Cover, and Biometry. Few teachers at the elementary level implemented MUC System or Land Cover Mapping, and even fewer implemented Accuracy Assessment. In the Soil investigation, recently trained teachers implemented protocols at rates typically equal to or higher than rates reported by teachers in the active-school sample. These data suggest that Soil protocols received greater emphasis in GLOBE training programs in 1998-1999 than in previous years, and that teaching teams at GLOBE schools are putting more effort into balancing implementation across investigation areas.

In general, trends in the implementation patterns of learning activities roughly parallel those of implementation trends for data collection protocols. Implementation rates in the Atmosphere investigation area have dropped slightly compared to those reported in the last survey in 1998, while rates in the other three areas, particularly Soil, have increased. Most of this change seems to be attributable to recently trained teachers, who are concentrating on the non-Atmosphere investigation areas more than their counterparts trained earlier did.

Teachers in our samples were asked in an open-ended survey item to explain the three chief factors that led them to implement certain protocols and learning activities and not others. Across samples, the most often-cited specific reason for choosing to implement a specific protocol or learning activity was a minimal time requirement followed by curriculum fit.

Analysis of Data Submissions

Teachers' survey reports of their use of GLOBE protocols can be compared with the pattern of submissions to the GLOBE Student Data Archive. As of mid-September 2000, 4,178 U.S. and international GLOBE schools had reported data to the archive since the beginning of the program in April of 1995. In 1999-2000, the number of schools reporting data rose by 10% over the previous year. Almost half of the 1,856 schools that reported data last year submitted data for at least 7 months of the year, and 359 submitted data for at least 10 months of the year. More than 400 schools submitted data between 4 and 6 months out of the year, and about one-fifth of reporting schools submitted data for a period of 2-3 months.

Atmosphere protocols remain far ahead of others in terms of the number of measurements reported each month. More than 900 schools report cloud and air temperature readings each month during the Northern Hemisphere's typical academic year. The number of schools reporting Hydrology data during these months has risen to around 265. Other investigation areas receive fewer data submissions. Some types of data are only intended to be reported once or on an annual or seasonal basis, however, and there were areas in which data submissions have significantly increased. The number of schools submitting Soil Characterizations rose from 23 in 1998-99 to 58 in 1999-2000. The number of schools reporting Land Cover Qualitative data rose from 170 to 312 during the same time frame.

Classroom Observations and Teacher Interviews

The evaluation team visited five GLOBE schools nominated as examples of active programs incorporating student investigations that build on GLOBE. Despite the varying grade levels and geographic variety in the schools we visited, we found common themes across the group of five. One of these commonalities was *administrator support*. All five of the lead GLOBE teachers at the case study schools had strong principal backing. This backing included not only financial support for attendance at training sessions and the purchase of needed equipment, but also cooperation in making arrangements for common teacher planning time, transportation to study sites, and general promotion of the program within the school community. A second theme was *involvement of colleagues*. In some cases, GLOBE protocols and learning activities were distributed across different classes. In other cases, other classes supported the program, for example, by making clinometers for use in taking biometry measurements. Case study teachers were also able to "leverage" time with their students through *creative classroom* *management* techniques, such as setting up structures for small-group work, with students taking on specific roles and rotating through those roles according to a schedule. Once such a structure was set up and students were trained in the various roles, student groups could execute multiple GLOBE activities simultaneously, with their teacher rotating from group to group to troubleshoot any problems or uncertainties that arose. These student groupings also *leveraged student expertise* and areas of high interest, giving a wide range of students the chance to contribute based on their "specialties." Case study teachers also increased time for GLOBE by designing activities in ways that did "double duty," preparing for or executing GLOBE activities while simultaneously *addressing required elements* in the locally mandated curriculum. Finally, all of the teachers in our site visit sample found ways to provide *a motivating local context* for GLOBE. They presented GLOBE measures as a way to objectively study the impact that various activities in their area were or were not having on the quality of their local environment.

Assessments of Student Learning

Teacher survey data, data reporting patterns in the Student Data Archive, and classroom observations all attest to the great variety of adaptations and the great range of the intensity of implementation of the GLOBE Program. What students learn from the program will, of course, depend on what parts of the program are implemented, how they are implemented, and how GLOBE activities are related to other aspects of students' school experience. To obtain some insights into these areas, we conducted a study of the students' environmental awareness and the ability to use data to make reasoned decisions on the part of high school students involved in GLOBE to varying degrees. One group came from GLOBE high school classes that contribute an above-average quantity of data to the Student Data Archive. A second group came from classes contributing an average amount of data to the archive. The third group was comprised of students of high school teachers who have signed up for GLOBE training but had not yet taken the training or started the program. Students worked in groups of two or three on two online assessment tasks.

On the environmental awareness task, GLOBE students tended to incorporate more important environmental concepts in their descriptions of an environmental scene than did non-GLOBE students ($p = .06$). When asked to describe how the water cycle works in this environment, GLOBE students provided significantly more elaborated descriptions of the phases of the water cycle than did non-GLOBE students. The amount of GLOBE data that their class had gathered did not predict the performance of students within the GLOBE classes (in fact, students from "average" GLOBE classes tended to use more environmental and water cycle concepts than those from classes that reported large amounts of data).

The second assessment task asked students to use environmental data to select a site meeting a complex set of climate-related criteria for the winter Olympics. After making a selection, students were required to develop a presentation including at least two data graphs that would support their recommendation. Students from classes that reported large amounts of GLOBE data tended to perform better on this assessment than the other two groups, which were similar. When teacher survey data were used to examine patterns of class activity, we found that the classes that reported large amounts of data also were more likely to engage in data analysis activities and explore the GLOBE Web site. An elaborated version of GLOBE in which students not only spend more time collecting data but also analyze and interpret that data and develop their own investigations appears more likely to support the development of general data-driven problem-solving skills.

Program Evolution

After five years of studying the GLOBE Program implementation, we can identify trends and features of the contexts in which GLOBE is implemented that have major influences on how GLOBE plays out in practice.

Teachers and schools will have different levels of involvement. While offering some unique features and advantages, GLOBE is just one of many programs and sets of science resources available to teachers. Not only do teachers have the choice of whether or not to take GLOBE training, but once they have completed the training, they have the choice of whether or not to use program elements, and if they do use elements, the choice of when and how to integrate them into their other school activities. While there are significant numbers of teachers who adhere to the original conception of GLOBE as a continuous data collection activity (at least during the academic year), there are also many teachers who implement GLOBE for 10 weeks or less and even some who choose to use learning activities without any data collection at all. The emphasis on learning activities relative to that on data collection appears to be on the rise. This variability is inevitable within the context of teacher and local decision-making around education as practiced in the United States. An implication of this state of affairs is that the individual educational resources need to be sufficiently rich and sufficiently self-explanatory that they can stand on their own.

GLOBE scientists need to be actively involved in recruiting and supporting the schools that provide data useful for their investigations. Given the various intensities of classroom involvement in GLOBE data collection activities discussed above, GLOBE's achievement of its goal to contribute to scientific knowledge is likely to depend on the energy and success with which the GLOBE scientists stimulate and support classroom involvement with their protocols. While the great majority of teachers embarking on GLOBE have used at least some of the Atmosphere protocols, the other investigations initially were implemented at lower rates—much lower in the case of Land Cover/Biology and Soil. Principal investigators for these areas have found that they need to recruit and motivate schools to use their data collection protocols. Personal contact with the scientists goes a long way toward maintaining school commitment and interest. Special events such as the MUC-Athens staged by the University of New Hampshire team can create a sense of urgency around GLOBE activities that helps GLOBE compete with the many other events in the school calendar (e.g., end of term examinations, performances, holiday parties, standardized testing periods).

The involvement of multiple teachers at a given school opens up opportunities for GLOBE to serve as a unifying theme within the science curriculum. The original recruiting concept behind GLOBE was to train one teacher for each school. In this way, it was thought that training dollars could impact the largest number of schools and consequently the largest number of students. As the complexity of GLOBE implementation became apparent and teacher turnover rates were considered, the GLOBE program began encouraging the training of multiple teachers from a given school. The data show that this trend toward training second and third teachers for a school, which was on the increase between Years 3 and 4, has continued to gather strength. Reports from the field suggest that the involvement of multiple teachers in GLOBE creates opportunities for curriculum integration across subject areas and articulation across years. Students who are introduced to GLOBE and one of its investigations in earlier years can proceed to tackle new investigation areas and increasingly complex data collection protocols and analysis activities in more advanced grades.

Many elementary teachers need continuing support in the area of science content. GLOBE is a content-rich program, and this is all to the good as it is not possible to teach scientific inquiry in the absence of a content domain. Nevertheless, this situation poses challenges for many elementary school teachers who themselves have very minimal science backgrounds. The fact that GLOBE is also inquiry oriented raises further challenges because teachers cannot predict ahead of time all the conceptual content that will be relevant as the inquiry progresses. Within the United States, elementary school teachers comprise the largest group of GLOBE implementers. Strategies for supporting these teachers' access to science knowledge, whether through additional education for the teachers or through the involvement of GLOBE scientists or of partner organization staff, parents, or community members with scientific expertise, are important.

The technology infrastructure required by GLOBE has diminished as a barrier to implementation. When the GLOBE Program started in 1995, issues surrounding technology use were prominent. Many teachers and administrators were attracted to GLOBE as an opportunity to do something educationally worthwhile with the new technology of the World Wide Web. Of those teachers who took GLOBE training during the first year but did not get the program going with their students, lack of Internet access was the most frequently cited barrier. This is no longer the case. Although teachers still may lack the convenient in-classroom Internet access they might want, lack of access is no longer among the top barriers cited by teachers who are not using the program. Nor is desire to try out a new technology frequently cited as a reason for getting involved with GLOBE. These changes are not surprising given the dramatic increase in web-based educational activities and in the availability of Internet access within U.S. schools.

Efforts to relate GLOBE to state and local curriculum standards appear to be helping. GLOBE teachers continue to see GLOBE's fit with mandated curricula and assessment systems as an issue. With encouragement from the GLOBE Program office, U.S. partners have been mapping elements of GLOBE onto their state standards and sharing these mappings with their teacher trainees. Individual GLOBE teachers are also taking on this challenge. Under a separate grant, SRI's assessment group is indexing GLOBE elements to the National Science Education Standards. Given the pressures that teachers face to cover a broad curriculum, such efforts are necessary if GLOBE is to find a significant place within regular classes. International partners also report that as national curriculum frameworks are being revised in directions that make them more "GLOBE friendly," opportunities to incorporate GLOBE into regular classes are increasing.

Summary

GLOBE has evolved in terms of the breadth and nature of its offerings, the range of implementation models it can support, and its basic teacher recruiting and training strategy (i.e., the shifts to multiple teachers per school and to the use of training partners). The less commonly taught and newer data collection protocols and associated learning activities are starting to penetrate GLOBE classrooms, largely through the efforts of recently trained teachers, many of whom appear to be focusing on protocols not used by others at their school. Learning activities have become nearly as common as data collection protocols in the program as implemented by recently trained teachers.

With all these changes, GLOBE's basic concept, the involvement of students and teachers in real scientific investigations, has not changed. The program is continuing its efforts to further enhance both the scientific and the educational value of this enterprise.

Chapter 1. Introduction

SRI International has provided evaluation services for the Global Learning and Observations to Benefit the Environment (GLOBE) program since 1995. For the past two years, SRI's evaluations have focused on providing data to help this international science and education program refine its partnership approach to teacher training and support. In the Year 5 evaluation, we have taken a closer look at the classroom adaptations of GLOBE, examining ways in which teachers have adapted elements of GLOBE to their particular classrooms and priorities as well as the institutional supports that facilitate sustained program participation.

The shift to an examination of classroom practices involving GLOBE seemed timely now that the great majority of the program's teachers are trained locally through partnerships established at universities, school districts, and other institutions. The flexibility and adaptability of GLOBE implementation remain the program's greatest strength and its greatest challenge. The program can be implemented under a wide range of circumstances (from kindergarten through 12th grade, with gifted students, students at risk, museum visitors, or individuals with sensory or learning impairments), and permits all kinds of adaptations. In addition, as GLOBE grows, so does the GLOBE Web database, which as of October 2000 was comprised of more than 5.7 million pieces of data. Now that this database has become a rich and complex resource for student investigations, using it effectively for scientific inquiry becomes an important priority. The current evaluation report pays particular attention to how inquiry skills, as applied to analyzing and interpreting scientific data, can be supported in the classroom.

To obtain our classroom data, we sent surveys to 1,000 U.S. teachers who were recently trained, and 500 U.S. and 200 non-U.S. teachers whose schools regularly submit at least four types of data to the GLOBE Web site. Surveys were returned by over 1,000 GLOBE teachers worldwide. This represents the largest survey of GLOBE teachers in the program's five-year history.

In addition to survey data on GLOBE classroom activities and instruction, we also sought more detailed information by conducting case studies. These studies focused on five GLOBE classrooms in different regions of the United States. Each classroom had demonstrated high use of GLOBE and incorporated elements of student inquiry and investigation into their GLOBE activities.

Finally, we assessed students' environmental awareness and their skills in scientific data analysis within both GLOBE and non-GLOBE classrooms. As part of this analysis, we also examined how variations in classroom activities contributed to differences in achievement among GLOBE students who participated in the program either frequently or moderately.

Program Description

GLOBE involves elementary and secondary students worldwide in measuring characteristics of their local atmosphere, water, soil, and land cover. Students engage in data collection processes designed by practicing scientists, and report their findings to a central Web site that becomes a resource for both GLOBE scientists and students. Since GLOBE began, GLOBE students have entered measurements into this archive and reviewed the resulting long-term environmental trends using tables, map visualizations, and graphing tools. The GLOBE Program (2001) cites 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.

Several U.S. government agencies provide support for GLOBE, which is headquartered in Washington, D.C. These agencies are 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. By October 2000, teachers from more than 9,658 schools in 95 countries had participated in GLOBE. Of these participants, 11,169 teachers were in the United States and 3,655 teachers were in other countries.

In spirit and design, GLOBE draws from research and science education reform movements employing inquiry and collaborative learning approaches. These approaches offer an alternative to conventional school science programs. Traditionally, educators treat scientific disciplines as isolated, static domains of knowledge that are given broad but superficial treatment. GLOBE involves students in multiple facets of environmental study and provides opportunities for in-depth involvement, including a way to contribute to a scientific database through the Web. In addition, GLOBE provides students with opportunities to interact with scientists. GLOBE seeks to help students generate their own questions and then conduct investigations by working with other students at their school or other GLOBE schools via the Internet.

As an educational program, GLOBE provides resources and a framework to support inquiry and collaboration across various scientific disciplines, but does not attempt to provide an Earth science curriculum. Since GLOBE is not a curriculum, teachers may adapt the program's resources to suit the needs of their classrooms and local environments. The program requires students to follow exacting data collection procedures using the correct instruments, but gives teachers the flexibility to decide which data would be most interesting to collect and analyze.

Program Evolution

The first edition of the GLOBE Teacher's Guide was distributed in March 1995. The second edition was released in 1997, and multiple supplements and new protocols have been released since then. The newest edition of the guide was not in use at the time data for this report were collected. Table 1.1 features the menu of protocols in use at the time of our data collection for this report.

In addition to the data collection protocols and associated learning activities that prepare students to conduct measurements, GLOBE includes many other functions and components. Students can learn much by exploring the GLOBE Web site: they can analyze existing data in the Student Data Archive, they can exchange GLOBEMail with other GLOBE schools, develop joint research projects, and submit their reports and findings for inclusion in the online Student Investigations journal. Activities involving use of MultiSpec software to manipulate satellite images are another open-ended aspect of the program.

Table 1.1*
GLOBE Data Collection Protocols

Atmosphere Investigation	***GPS Investigation***
Min/Max/Current Temperature	GPS
Rainfall	Offset GPS
Solid Precipitation	
Precipitation pH	
Cloud Cover	
Cloud Type	
Hydrology Investigation	***Soil 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	Optional Gypsum Block Soil Moisture
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	

*These protocols were current as of January 2000.

During the program's first year of operation, GLOBE's administrators recruited teachers through an advertisement in the Federal Register. GLOBE's administrators required schools to commit to a full-time data collection schedule (including weekends and school vacations) and three years of participation.

Training for teachers began at a dozen university sites across the United States in 1995, and more than 1,500 teachers received GLOBE training that year. Typically, each school sent one teacher for GLOBE training. As the program matured and started working on strategies to expand involvement, GLOBE leadership developed the partnership training model. This option allowed the program to expand teacher training more cost-effectively and provide better ongoing support for GLOBE teachers. Under this model, the GLOBE Program enters into a no-exchange-of-funds partnership with a university, school district, science center, or other nonprofit entity interested in providing GLOBE training in its service area. To provide teachers with a network of colleagues sharing in GLOBE implementation, GLOBE administrators encourage teachers to attend training sessions in groups. The proximity of partner organizations to the schools whose teachers they recruit facilitates this approach.

International Partners

Because broad international participation is integral to the implementation of the program, GLOBE enters into formal agreements with countries all over the world. GLOBE provides the program infrastructure, while international partners manage their own implementation, including selecting their own coordinator, deciding how many and which schools to sponsor, and determining how GLOBE will be implemented in its schools.

It took time for international partners to identify the funding, organizational supports, school participants, and needed equipment necessary for GLOBE implementation. 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, GLOBE international participation grew to 2,675 non-U.S. schools by October 2000.

Evaluation Evolution

From the beginning, SRI International has tracked the progress of GLOBE's development, expansion, and impacts on student learning. The Year 2 evaluation (Means et al., 1997) identified key issues for discussion and improvement, from providing classroom and teacher support to improving assessment. The same report also emphasized the importance of encouraging collegial support for GLOBE at school sites, developing grade-appropriate learning activities, and encouraging teachers to use more of the GLOBE data collection protocols. The Year 3 evaluation focused on developing student achievement measures, and the Year 4 evaluation focused on the effectiveness of recruiting, training, and follow-up support practices of GLOBE international and U.S. partners. As the GLOBE Program has continued to evolve, it has taken steps to enhance practices in these areas. In our Year 5 evaluation, we have found that the more successful GLOBE schools and teachers have adopted many of the principles cited in SRI's earlier evaluation reports.

Report Overview

This report focuses on classroom practices that lead to successful adaptation and implementation of GLOBE. Chapter 2 describes the methods we used for data collection. Chapter 3 describes the growth of the GLOBE Program as indexed by the teacher training database and the Student Data Archive. Chapter 4 discusses the characteristics of GLOBE implementation in schools and classrooms, based on responses to the teacher survey. Chapter 5 describes the findings of the case studies at five schools around the United States. Chapter 6 discusses recent activities in the international program. Chapter 7 reports findings from the administration of the student performance assessment tasks. Chapter 8 summarizes the main findings and trends.

Chapter 2. Methodology

The 1999-2000 year is the fifth full school year of GLOBE implementation. In this chapter, we provide an overview of the data sources and methodology applied in our Year 5 evaluation activities, and describe the five main sources of information used: the database developed by GLOBE, SRI's teacher survey, Country Coordinator interviews, case studies, and Web-based assessments of student learning.

GLOBE Database

NOAA maintains the GLOBE Student Data Archive, to which students submit their measurements. The data archive contains the GLOBE measurements along with the name and location of the school submitting the data, the type of data, and the date on which the data were collected. Contact information on schools, teachers, and principals, as well as information about each teacher's GLOBE training was formerly maintained in a separate master database of "registered" U.S. GLOBE schools, but is now a part of the same Oracle database containing the GLOBE Student Data Archive.

In the data archive, GLOBE measurements are associated with the students' school but are not linked to a particular teacher. Although practical for the database's intended use—analyzing environmental data by site—this arrangement precludes certain types of analysis (e.g., relating teacher characteristics to data reporting) that would be useful for evaluation purposes. SRI has been exploring ways to mine the Student Data Archive for useful information about patterns of GLOBE implementation in different kinds of educational settings.

Statistics from the GLOBE Student Data Archive have been used in the analysis of GLOBE program growth presented in Chapter 3 of this report. In that chapter, we describe the growth of the program in terms of the number of schools reporting data, number of teachers trained, and frequencies and types of data reported. Where consistency of data reporting formats allows, we have explored trends in data reporting practices across different years of GLOBE implementation.

Teacher Survey

A GLOBE teacher survey, with many of the same questions that were asked in earlier surveys, was administered in the spring of 2000. The GLOBE teacher survey includes questions about GLOBE protocols, learning activities, and other GLOBE components that schools have implemented in the past year, as well as questions about important background characteristics, such as grade levels and settings in which GLOBE is implemented at teachers' schools. The entire survey appears in Appendix A.

The survey was administered to three different samples of GLOBE teachers: (1) recently trained U.S. teachers; (2) active data-reporting U.S. teachers, and (3) active non-U.S. or international teachers.[1]

Recently Trained U.S. Teacher Sample. The first survey sample was designed to be representative of U.S. teachers recently trained in GLOBE. To construct the first sample, we selected 1,000 U.S. teachers at random from those U.S. teachers who received GLOBE training between June 1998 and August 1999. A survey notice letter explaining the purpose of the survey was mailed to these 1,000 teachers on March 17, 2000, followed by the survey and a cover letter mailed March 29, 2000. The cover letter included a URL that teachers could use to complete the survey online. On April 17, 2000, reminder postcards asking nonrespondents to complete the survey were mailed. A second reminder mailing with a cover letter from GLOBE Director Tom Pyke and a second copy of the survey was mailed to nonrespondents on May 2, 2000. Starting May 8, an extensive telephone and e-mail follow-up campaign was initiated that lasted through the first week of June 2000. The final survey response count included 512 teachers, just over half of all recently trained teachers who were mailed surveys.

Active U.S. Teacher Sample. To create this sample, SRI used data from the GLOBE Student Data Archive to identify a sample of 500 schools that regularly submitted data on at least four Atmosphere scientific protocols to the GLOBE Web site from December 1999-February 2000. On March 21, 2000, a notice letter explaining the purpose of the survey was mailed to either the GLOBE teacher at the school, for those schools with only one GLOBE teacher, or to the "GLOBE Team," for those schools with more than one teacher. The letter addressed to "GLOBE Team" asked the team to identify the most active GLOBE teacher and to provide that information on an enclosed business-reply

[1] Throughout this report, the term "active teachers" is used to denote teachers from schools that are above-average in terms of frequency of reporting GLOBE data.

postcard or by e-mail to SRI. The survey and cover letter were mailed to these identified teachers between March 29 and April 3, 2000. The cover letter included a URL that teachers could use to complete the survey online. As with the trained-teacher sample, reminder postcards were mailed to nonrespondents on April 17, 2000. The follow-up procedures for nonrespondents were the same as those for the trained teacher sample. Surveys were returned by 390 of the active U.S. teachers, for a response rate of 78%.

Active International Sample. A random sample of 200 schools outside the United States that submitted data on at least four Atmosphere scientific protocols to the GLOBE Web site from December 1999-February 2000 were sent teacher surveys to complete. E-mail notices were sent to the Country Coordinators for each partner country with a school in the sample by Lyn Wigbels, GLOBE Assistant Director for International Programs. This e-mail included a list of the schools selected for the random sample of active schools and a listing of GLOBE teachers at each school. The e-mail asked the Country Coordinators to choose whether the survey packages should be mailed directly to the schools or to the Country Coordinator for distribution. The survey and a cover letter explaining its purpose were mailed either to the teachers or to the Country Coordinator for each country in April 2000. The cover letter included a URL that teachers could use to complete the survey on-line. Follow-up efforts in the form of e-mails to Country Coordinators were sent from May 15 through May 22, 2000, asking them to contact nonrespondent schools. Survey packages were mailed again to nonresponding schools or to Country Coordinators for distribution on May 22, 2000. Additional e-mail follow-up was conducted with Country Coordinators to urge any nonresponding schools to complete the surveys. Surveys were returned by 131 active international teachers, for a response rate of 66%.[2]

Table 2.1 summarizes the populations, samples, and response rates for the Year 5 teacher survey.[3]

The first of these samples—U.S. trained teachers—helps us understand the ways in which the typical U.S. teacher's practice is influenced by GLOBE training and the factors associated with greater and lesser use of GLOBE in teachers' classrooms. This sample

[2] The assistance of the Country Coordinators and Lyn Wigbels was a key factor in improving the response rate for Year 5 dramatically over the 36% we received in Year 3.

[3] Survey respondents' schools did not significantly differ from respondents on two indices of GLOBE program implementation, their likelihood of reporting any data to the GLOBE Student Data Archive and their consistency in data reporting. Therefore, the responses of those teachers who completed the survey are likely to be similar to those of teachers who did not.

Table 2.1
GLOBE Teacher Survey Samples and Response Rates

	Population	*Surveys Mailed*	*Surveys Completed*	*Response Rate (Percent)*
U.S. Trained Teacher Sample	2,918	1,000	512	51
U.S. Active Teacher Sample	537	500	390	78
Int’l Active Teacher Sample	359	200	131	66

includes teachers who completed GLOBE training but never implemented the program in their classrooms and helps us understand the reasons why some teachers decided not to participate further. The second sample, active U.S. teachers, tells us what GLOBE looks like when it is implemented in U.S. classrooms in an ongoing manner. This sample provides reports of the supports in place in those schools as well as the challenges that teachers have encountered and the effects that GLOBE teachers believe the program is having on their students. Comparisons of the trained teacher survey results with the active U.S. teacher survey results also provide insights into factors that help explain why GLOBE is implemented in some schools but not in others. Finally, the third sample of active international schools provides a portrait of implementation in non-U.S. settings and allows points of comparison with U.S. active schools.

Country Coordinator Interviews

A number of Country Coordinators were interviewed at the annual GLOBE conference in Annapolis, Maryland in summer 2000. Selected coordinators (primarily those for countries with active programs) have been interviewed by SRI researchers each summer since 1997. Information provided by these coordinators has been used to provide specific examples of international GLOBE program practices, complementing the reports of classroom practices from the GLOBE teacher survey with a description of recruiting, training, and follow-up support practices at the country program level. Information provided by the Country Coordinators is discussed in Chapter 6.

Case Studies

Each year of the GLOBE evaluation, SRI has conducted site visits to selected schools across the United States that have been active in the GLOBE Program. In previous years, SRI selected a slate of potential candidate schools primarily on the basis of their contributions to the Student Data Archive and on their geographic diversity. While data submissions are an important part of GLOBE, we know there are other ways that a school's program might illustrate innovative uses of GLOBE content adapted to a local school setting. For example, GLOBE activities might be unusually well integrated with the core curriculum, implemented by large numbers of teachers, or involve significant participation of parents or outside experts. To learn more about ways that schools are successfully integrating GLOBE into meaningful learning opportunities for students, SRI sought to identify a selection of GLOBE sites across grade levels and geographic regions that reflected different successful innovations in program implementation.

SRI researchers screened schools that were nominated or self-selected in response to a nationwide call for participation via the GLOBE listserv. The screener asked questions about how GLOBE was being implemented at the school, special innovations or adaptations of GLOBE within the school, and ideal times that an SRI researcher could visit to see GLOBE being implemented. From the results of this screening, SRI identified five sites to visit that had demonstrated extensive use of GLOBE protocols and learning activities and that had incorporated elements of student inquiry and investigation into their GLOBE activities.

During the site visits, we observed GLOBE data collection and related classroom activities. We talked with teachers about their goals for student learning, their classroom management strategies, and their perceptions of the major barriers to GLOBE implementation. We interviewed GLOBE-trained teachers who were not implementing the program to understand their perceptions of the program. We talked with principals and partner coordinators about the differences they observed between teachers who adopted GLOBE after training and those who barely used it.

After conducting on-site observations and interviews at each of the five case study sites, researchers prepared “debriefing forms” describing each site’s practices in a standard format. These debriefing forms were then analyzed to identify compelling examples and cross-cutting themes, especially as related to implementation variables that distinguish active from inactive GLOBE-trained teachers.

Assessment of Student Learning

In Year 5, SRI refined the two online performance assessments used in Year 4 to measure students' environmental awareness and skill in developing well-reasoned arguments using GLOBE-like data as evidence. These tasks are described in greater detail in the Year 4 report, in Chapter 7 of this report. In short, the online performance tasks require students to describe relationships among elements in an image of a natural environment and to decide from among a list of cities the ideal site to host the Winter Olympics, based on temperature and precipitation data provided in the assessment task. The Winter Olympic task represents what psychologists call a "far transfer" task; in other words, it tests whether students can apply the skills that GLOBE students may learn during the course of collecting and analyzing data about the environment to an entirely new context. GLOBE students do not typically solve the kind of problem that is presented to them in our assessment task, but they would be familiar with the terms used and the kind of data presented to them to use to solve the problem. To analyze what students are learning from GLOBE, we compared the performances on the two assessment tasks across high school students from three groups of classrooms: (1) "high-reporting" GLOBE classrooms, (2) "average-reporting" GLOBE classrooms, and (3) a comparison group of classes whose teachers had signed up for GLOBE training, but had not yet implemented the program. The high-reporting GLOBE classrooms were randomly selected from high schools reporting the most data to the GLOBE Student Data Archive during the fall of 1999. The number of reports these schools submitted placed them more than one standard deviation above the average number of reports submitted. The average-reporting classrooms were randomly selected from those high schools whose number of total data reports for fall 1999 clustered around the average for all GLOBE schools. Comparison teachers were randomly selected from among a pool of teachers who had signed up for GLOBE training but who had not yet received training or begun implementing GLOBE. The most recent semester of data collection was used as the basis for selection of classrooms, since there is wide variation in implementation from year to year for particular schools.

Each of the selected schools was contacted by an SRI researcher to determine whether the school had the necessary technical configuration to use the online assessments. For schools selected for the assessment study sample, basic data about GLOBE implementation and student performance levels in the classrooms were collected via a pencil-and-paper survey. Next, each classroom that agreed to participate collected signed permission forms from parents of all student participants in the assessment.

Because the collection of GLOBE data typically is performed by students working in small groups, we designed the online assessment as a group activity. This design choice also reduced the amount of technology access a class needed in order to participate. Classroom teachers divided their classes into groups of 3-4 students each, and logged onto the assessment Web site using a unique ID and password assigned to each group. Students worked in their small groups then to complete the online assessment tasks, which took one or two class periods to finish. With the significant refinements to the design of the assessment Web site made by SRI after pilot-testing the assessments in Year 4, the classrooms participating in the Year 5 study encountered few technical difficulties. The increased availability of faster Internet connections in schools may have also contributed to the schools' ability to participate.

The data analyzed in this report include results from 93 different student groups from 32 schools that administered the assessments. While the number of groups who completed the study were not equal across all samples (high-reporting, average-reporting, and comparison), we selected 31 student groups at random from each sample for our data coding and analysis.

Discussion

The use of data from multiple sources and methods allows us to get a clearer picture of how implementation of the GLOBE Program varies and how implementation may be shaping student learning. The teacher survey helps identify broad patterns in implementation, and the case studies help address questions raised by the patterns in those data. Detailed descriptions of how GLOBE is being implemented provide a deeper understanding, for example, of how different schools integrate GLOBE into the curriculum at different levels. Likewise, examining the ways that GLOBE teachers are incorporating student inquiry into their classrooms helps account for findings in our assessment of student learning. Our concluding chapter draws these kinds of connections among the various sources of data and makes recommendations for future directions that GLOBE could explore to improve implementation quality and augment the gains in student learning already documented by the evaluation.

Chapter 3. Program Growth

The GLOBE Program has expanded training of teachers in the United States by partner organizations and continues to bring new partner countries into the program. This chapter summarizes patterns in growth in the number of teachers trained, number of schools reporting data, and number of reports of each type of data submitted each month. Where comparable data are available, comparisons are presented for Years 1 through 5.[1]

The Number of Teachers Trained

The growth of active teacher-training partners in the United States and the increase in the number of international GLOBE partners has brought the number of teachers trained to approximately 14,775 since GLOBE's inception in 1995. As of mid-September 2000, more than 11,100 teachers had been trained in the United States and more than 3,600 had been trained internationally. A record 3,863 teachers were trained during the year September 1999 to August 2000. U.S. partners trained nearly 3,000 teachers, and GLOBE partner countries trained almost 900. The program is continuing to promote the concept of training more than one teacher per school to allow teachers to benefit from a local support network. This strategy has been paying off in the broader implementation of protocols by schools that have more than one trained GLOBE teacher (discussed in Chapter 4) and in the increase in number of schools reporting data in most of the GLOBE investigation areas.

Figure 3.1 depicts the cumulative growth in the number of U.S. teachers trained since 1995. The number of teachers trained in the United States has nearly doubled since the fall of 1998. However, the large number of teachers trained has not led directly to comparable growth in implementation of the program in U.S. schools. The number of schools reporting GLOBE data has risen, but less dramatically than the number of teachers trained, as will be discussed later in this chapter.

Figure 3.2 shows the number of U.S. teachers trained by year from 1995 through August of 2000. In terms of teacher training, GLOBE's partner model appears to be a successful strategy for scaling up the program without a major increase in costs. Under this model, the GLOBE Program enters into a no-exchange-of-funds partnership with

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[1] Our thanks to Len Gallagher at the National Institute of Standards and Technology and Mike Turpin at Forecast Systems Laboratory for their assistance in obtaining the data for these analyses.

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

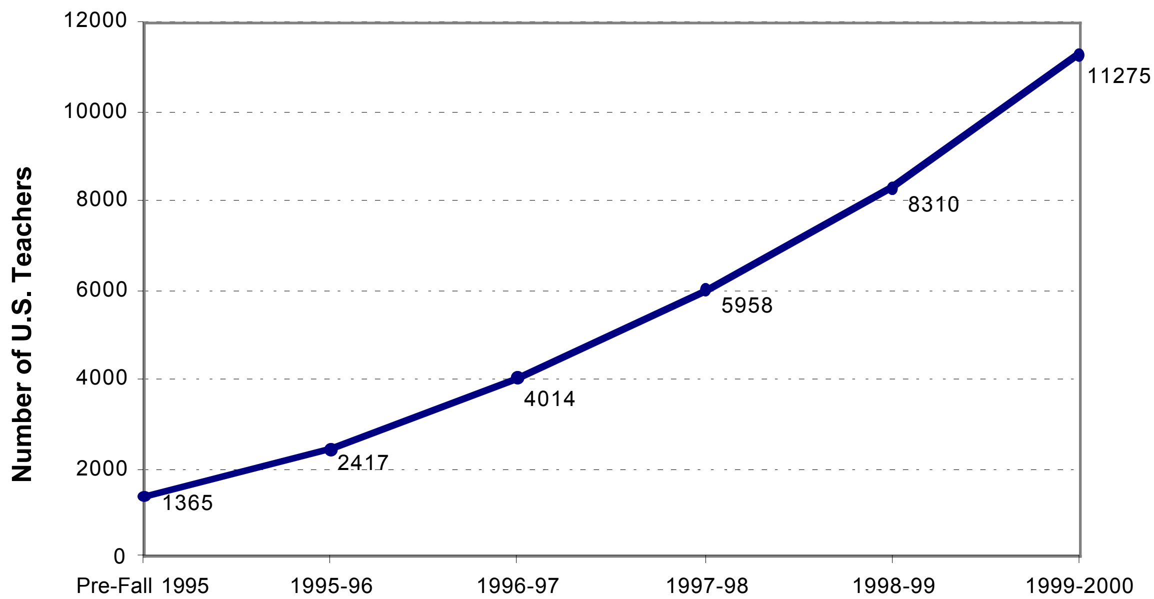
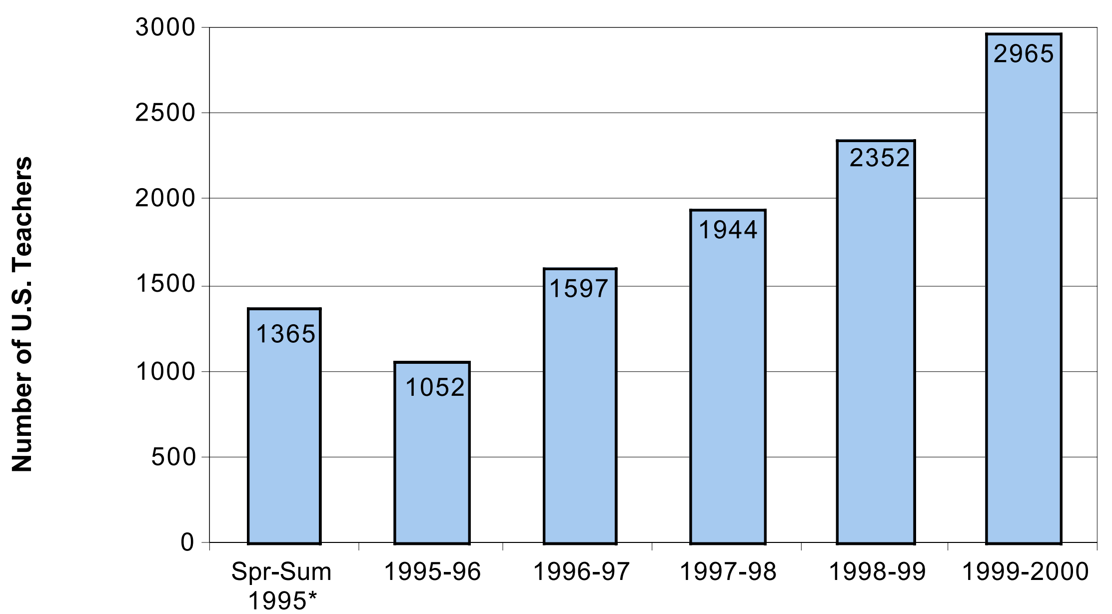


Figure 3.2
Number of U.S. Teachers Trained, by Year



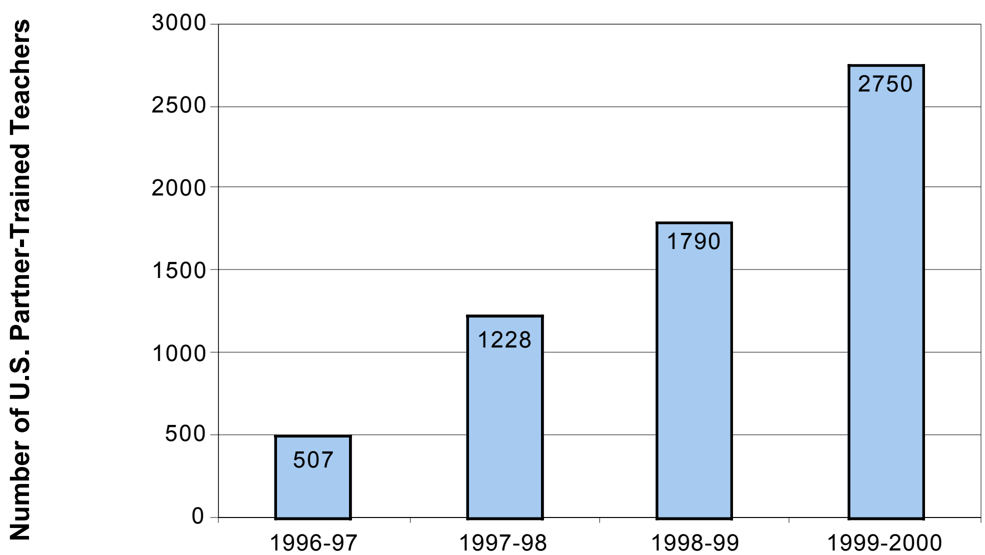
Note: Bars depict 12-month (September-August) training totals except where otherwise noted.

Teacher training began in spring 1995. A large number of teachers were trained in the program's first 6 months to provide a critical mass of teachers ready to begin the program in school year 1995-96.

a university, school district, science center, or other nonprofit entity interested in providing GLOBE teacher training in its service area. The partner sends its trainers to a GLOBE train-the-trainer workshop and receives GLOBE materials for distribution to the teachers it trains. Partners leverage the federal investment in GLOBE's scientific, technical, and educational infrastructure but are responsible for paying their own operating costs.

Figure 3.3 shows the number of U.S. teachers trained during the last year by partner organizations. Comparing Figures 3.3 and 3.2, one can see that GLOBE teachers in the United States are now trained almost exclusively by partners rather than trainers working under contract to the GLOBE Program office. Ninety-three percent of U.S. teachers received their training from a partner organization in 1999-2000, compared with 76% in 1998-99, and 63% in 1997-98.

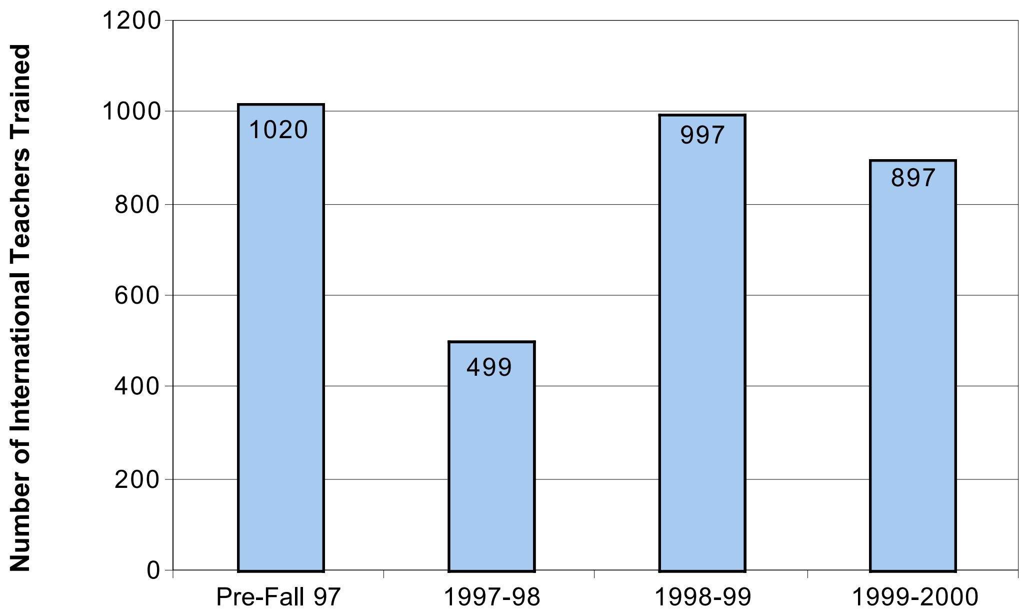
Figure 3.3
Number of U.S. Partner-Trained Teachers, by Year



Among U.S. states with GLOBE partner organizations, Texas trained the largest number of teachers (almost 300) in 1999-2000, followed by the state of North Carolina with over 200 teachers trained during that school year. The state of North Carolina has revised its middle school science curriculum to be congruent with GLOBE, and has begun a massive effort to encourage partner organizations to train about 300 teachers per year for the next 2 years.

Figure 3.4 shows that the number of international teachers receiving GLOBE training has remained relatively stable over the last year, after experiencing significant growth from Year 3 to Year 4. (Before February 1998, international teachers' date of training was not tracked in the GLOBE master database. Data in Figure 3.4 have been constructed in part on the basis of prior analyses and teacher identification numbers.) Many of the international partners that have been involved in the program for several years reported that in 1999-2000 they focused their efforts more on supporting existing GLOBE teachers with additional training than on recruiting new teachers. In fact, a few of these partners did not train any new teachers in the last year so that they could concentrate all of their limited resources on supporting existing GLOBE teachers.

Figure 3.4
Number of International Teachers Trained, by Year

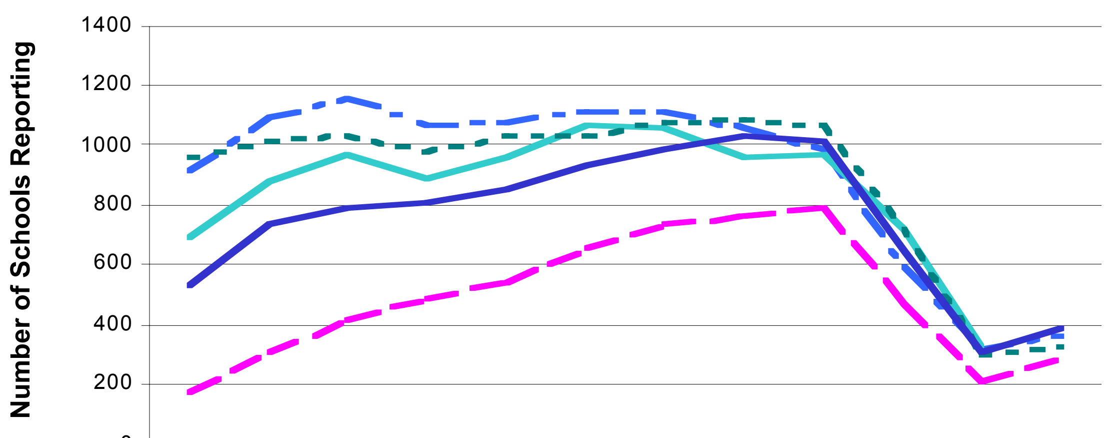


The record of school data reporting provides some evidence of the need for such follow-up activities with already trained teachers. Over the 5-year life of the program, 40% of U.S. schools and 55% of international schools with GLOBE-trained teachers have reported data. During the period September 1999 to August 2000, 14% of U.S. schools and 33% of international schools with GLOBE-trained teachers reported data.

Number of Reporting Schools

As of mid-September 2000, 4,178 U.S. and international GLOBE schools had reported data since the beginning of the program in April of 1995. Figure 3.5 shows that the number of schools reporting data grew each month from September through April during the first 2 years of the program. During GLOBE's third year, the number of schools reporting monthly during the Northern Hemisphere's school year leveled off at between roughly 900 and 1,100 schools. The following year (Year 4) actually saw a modest drop in reporting for most months of the academic year. In 1999-2000, reporting levels rose again. More than 1,850 different schools reported data during the period from September 1999 through August 2000. The fact that fewer than 1,200 schools have ever reported data in any one month indicates that many schools report intermittently with new schools starting to participate or renewing participation while other schools cease submitting measurements. Generally, between 250 and 300 schools submit GLOBE data each weekday during the Northern Hemisphere's school year (the data they report may be for more than one day).

Figure 3.5
Number of Schools Reporting Data in GLOBE Years 1-5, by Month



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
99-2000	916	1091	1156	1070	1075	1115	1115	1058	985	591	311	367
98-99	692	882	972	896	961	1071	1060	967	974	721	323	
97-98	960	1014	1032	976	1026	1028	1078	1084	1065	720	301	322
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

One of the GLOBE Program's objectives has been to increase the consistency and duration of school data reporting. Our analysis of school data reporting patterns (see Figure 3.6) suggests that many schools are reporting GLOBE data for a significant period of time. Almost half of the 1,856 schools that reported data last year submitted data at least 7 months of the year, and 359 of these frequently-reporting schools submitted data for at least 10 months of the year. More than 400 schools submitted data between 4 and 6 months out of the year, and about one-fifth of reporting schools submitted data for a period of 2-3 months. These data-reporting patterns in the Student Data Archive are congruent with active teachers' survey responses regarding the number of weeks that GLOBE is used in their classrooms. Forty-nine percent of these teachers indicated that they used GLOBE for more than 30 weeks out of the year (see Figure 4.2 in the next chapter).

Figure 3.6
School Reporting Patterns from September 1999 through August 2000

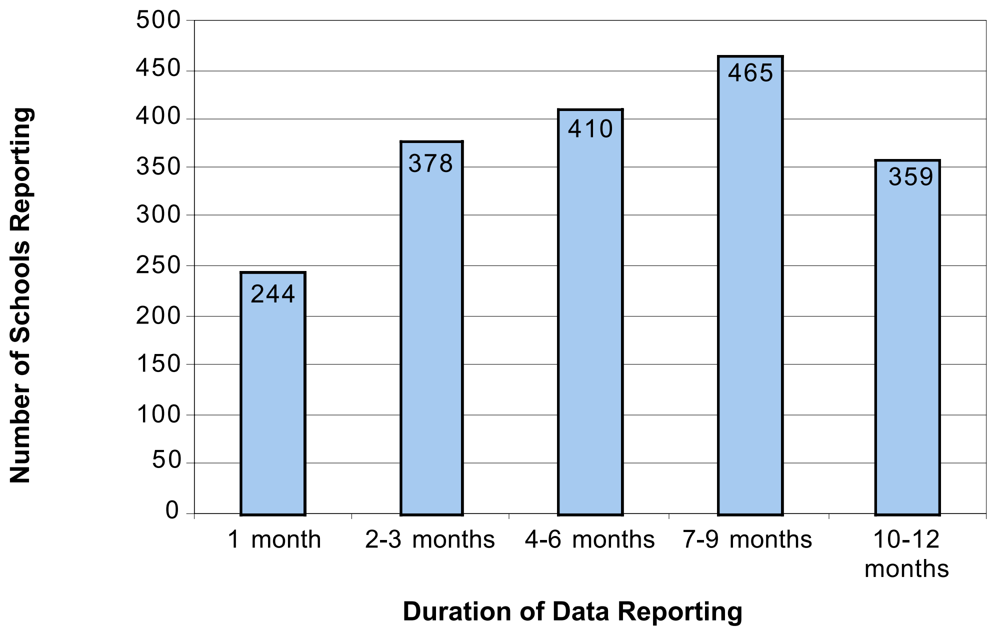
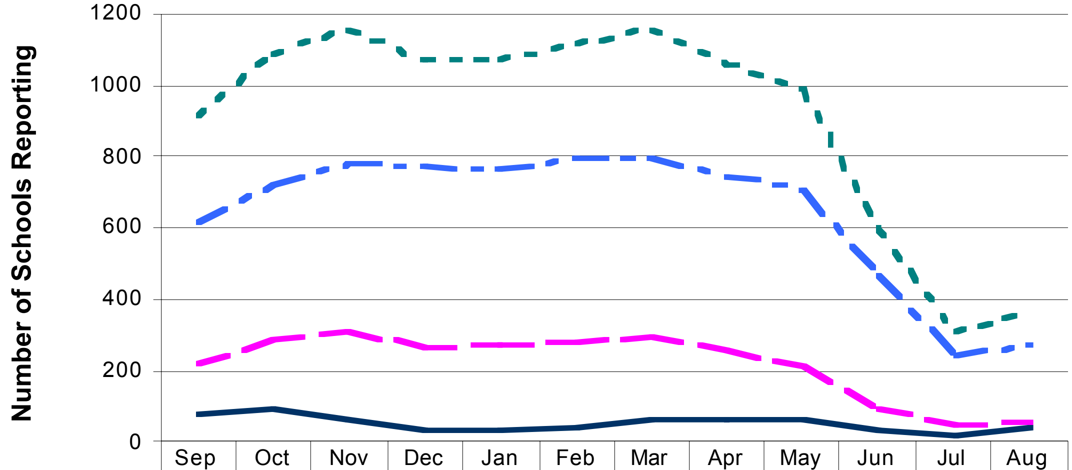


Figure 3.6a shows an analysis comparing schools reporting data during the 1999-2000 school year grouped by reporting frequency of more than 6 months of the year, between 3 and 6 months of the year, and less than 3 months of the year. Schools reporting more than 6 months of the year and those reporting between 3 and 6 months of the year show remarkably similar patterns over the months. The smaller group of schools reporting data for less than 3 months tends to report more data at the beginning of the school year and/or in the spring.

Figure 3.6a
School Reporting Patterns by Month and Reporting Frequency, September 1999 through August 2000



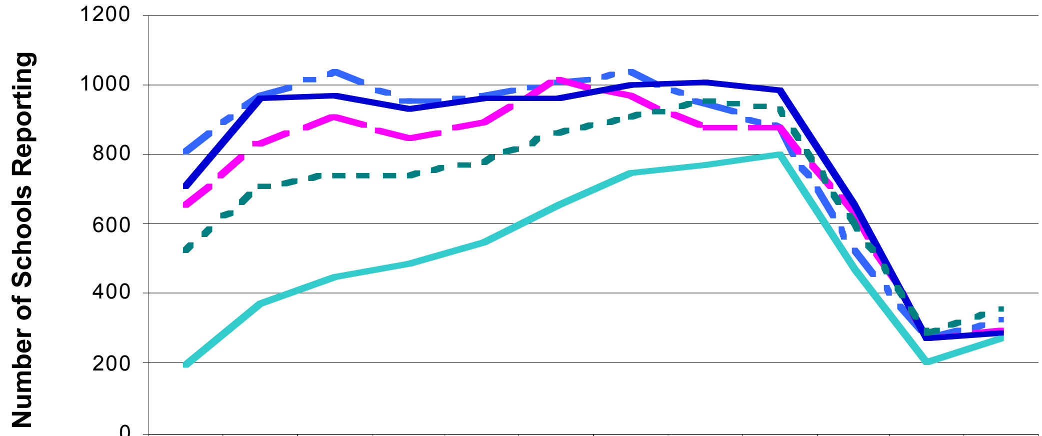
	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
> 6 mos	617	720	781	773	766	792	795	748	712	465	242	271
3-6 mos	219	283	308	264	270	281	300	252	212	95	51	53
< 3 mos	80	88	67	33	39	42	60	58	61	31	18	43
total	916	1091	1156	1070	1075	1115	1155	1058	985	591	311	367

Reporting Patterns for Different Data Types

Figures 3.7 through 3.12 present the number of schools reporting daily measurements for Cloud Observations, Air Temperature, Liquid Precipitation, and Solid Precipitation.

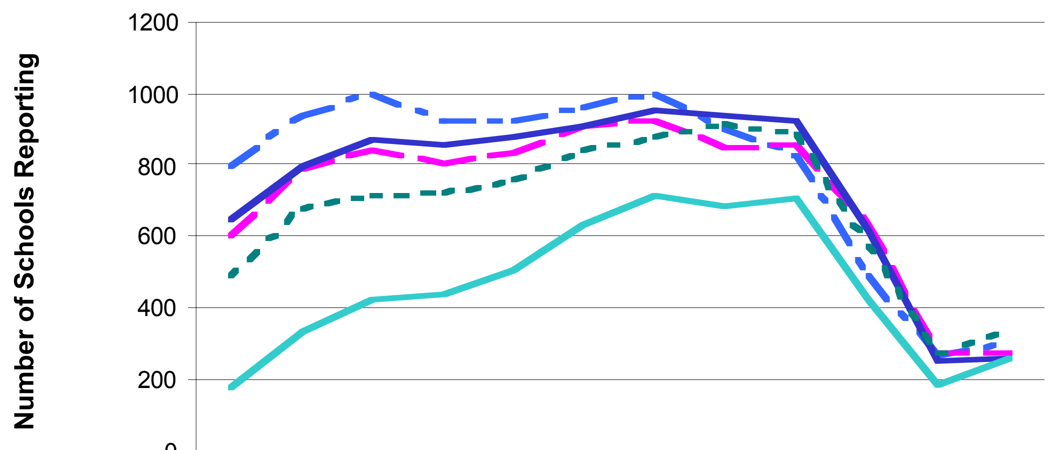
As in the past, Cloud Observations (Figure 3.7) are still the most frequently and consistently reported data type. The fact that these protocols can be implemented without special equipment and are easily adaptable to the range of grade levels participating in GLOBE makes them a popular choice, especially for schools that are just beginning to implement the program. For both Cloud Observations and Air Temperature (Figure 3.8) schools reported more observations in September 1999 than in September 1998, suggesting that schools are organizing GLOBE activities earlier in the school year than in past years.

Figure 3.7
Number of Schools Reporting Cloud Observation Data, by Month and Year



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Cloud 99-2000	808	968	1034	952	970	1006	1038	942	875	522	273	322
Cloud 98-99	653	832	905	846	897	1011	969	879	875	632	273	293
Cloud 97-98	709	965	966	930	962	961	1000	1006	988	651	273	288
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

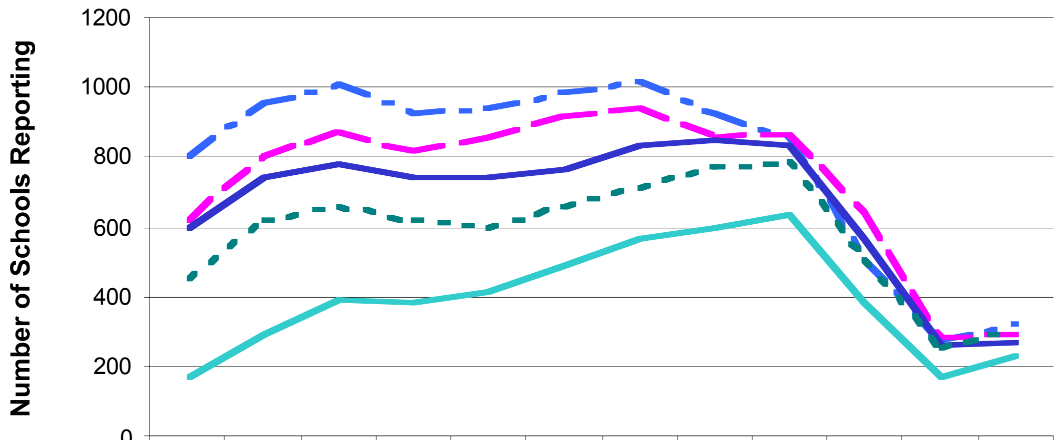
Figure 3.8
Number of Schools Reporting Air Temperature Data, by Month and Year



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Air Temp 99-2000	802	941	998	925	921	965	1003	904	828	491	264	305
Air Temp 98-99	606	787	844	808	837	912	928	847	854	633	278	276
Air Temp 97-98	651	798	873	860	880	908	957	942	927	619	257	261
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

Figures 3.9 and 3.10 show that the margin of growth attained in Air Temperature data reporting of between 100 and 200 schools each month is also reflected in the numbers for Liquid and Solid Precipitation measurements. Since September of 1998, the GLOBE reporting form has required that schools reporting Air Temperature and Cloud Observation data must also submit precipitation measurements (or indicate that there was no measurable precipitation) in order for any of the measurements to be accepted for submission. This requirement has likely increased the amount of precipitation data in the GLOBE database, but may be frustrating to teachers and students who have not yet obtained equipment for the precipitation protocols and have only Cloud Observations to report.

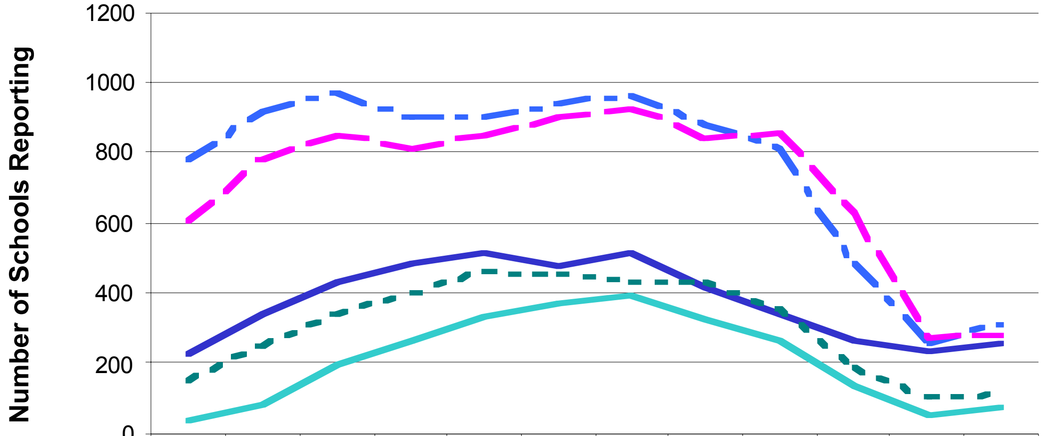
Figure 3.9
Number of Schools Reporting Liquid Precipitation Data, by Month and Year



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Rain 99-2000	808	954	1007	930	942	981	1011	919	853	511	277	319
Rain 98-99	622	802	872	821	854	915	938	855	865	640	282	288
Rain 97-98	601	741	782	737	747	765	833	849	833	561	260	272
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

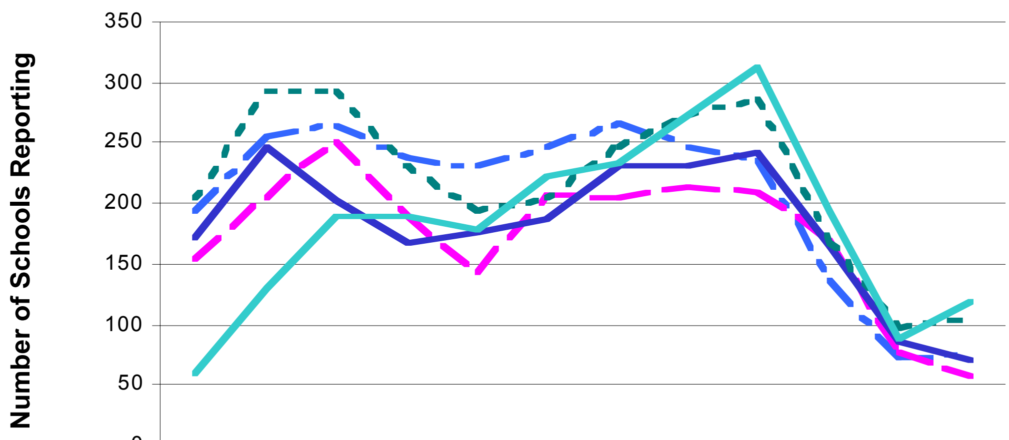
More consistent reporting of Hydrology data has smoothed the peaks and valleys of previous years, as shown in Figure 3.11. Changes in the protocol frequency requirements for Hydrology—from weekly (Years 1 and 2), to monthly (Year 3), to at least monthly but weekly if possible (Year 4)—have made comparisons across reporting years difficult to interpret. Nevertheless, it is clear that schools were implementing these protocols and reporting measurements more consistently in 1999-2000 than in past years.   It is also interesting to note that reporting during the winter months, which typically has

Figure 3.10
Number of Schools Reporting Solid Precipitation Data, by Month and Year



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Snow 99-2000	780	918	968	897	903	938	963	878	815	481	259	315
Snow 98-99	605	785	850	814	849	899	928	847	857	627	270	282
Snow 97-98	229	344	433	485	510	479	515	415	340	267	237	258
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

Figure 3.11
Number of Schools Reporting Hydrology Data, by Month and Year

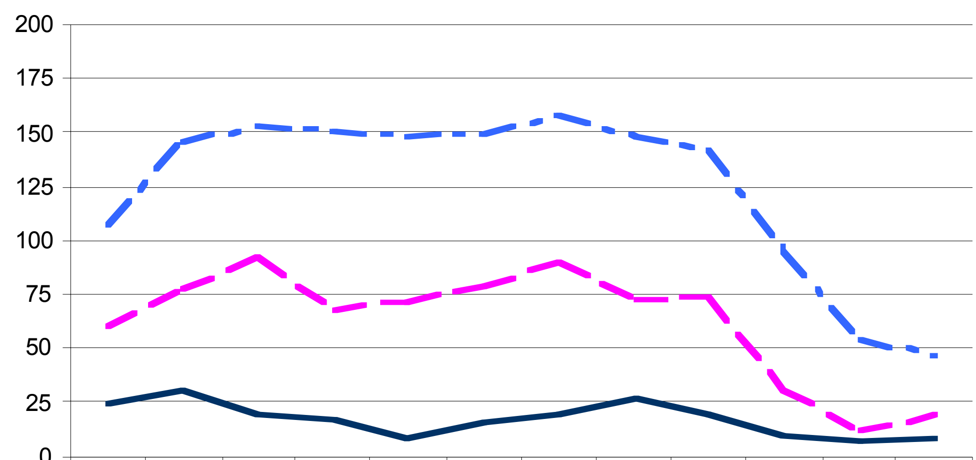


	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Hydrology 99-2000	193	255	264	236	229	245	267	248	235	136	73	75
Hydrology 98-99	154	206	250	190	143	208	206	213	209	169	77	57
Hydrology 97-98	172	247	202	168	176	186	230	229	242	165	86	71
Hydrology 96-97	203	292	293	229	194	203	247	274	286	167	98	106
Hydrology 95-96	59	129	189	189	178	222	234	272	312	193	87	119

been low in the past, is now much higher and more consistent with other months of the school year. In part, this may reflect teachers heeding scientists' messages concerning the importance of sustained, consistent data sets. Another likely factor is a change in the reporting form to require classification of the water source as Normal State, Frozen, Dried, Flooded, or Unreachable. Out of 9,827 reports made September 1999 through August 2000, 626 had codes stating frozen (457), dried (20), flooded (140), or unreachable (9). This number represents 6% of all reports for 1999-2000. In 1998-99, 188 out of 9,385 reports had these codes (2%). Schools are becoming more accustomed to providing this metadata and may be more likely to continue to do so during winter months where in earlier years they tended simply not to file reports.

Figure 3.11a compares Hydrology reporting patterns of schools during the 1999-2000 school year, broken down into 3 groups by duration of data reporting: more than 6 months, between 3 and 6 months, and less than 3 months. Out of the 497 schools that reported Hydrology data at some point during the year, approximately one-third of that number fall into each of the 3 reporting duration groups, with the steady reporting group (> 6 months) showing higher consistency from October through May than the other two groups.

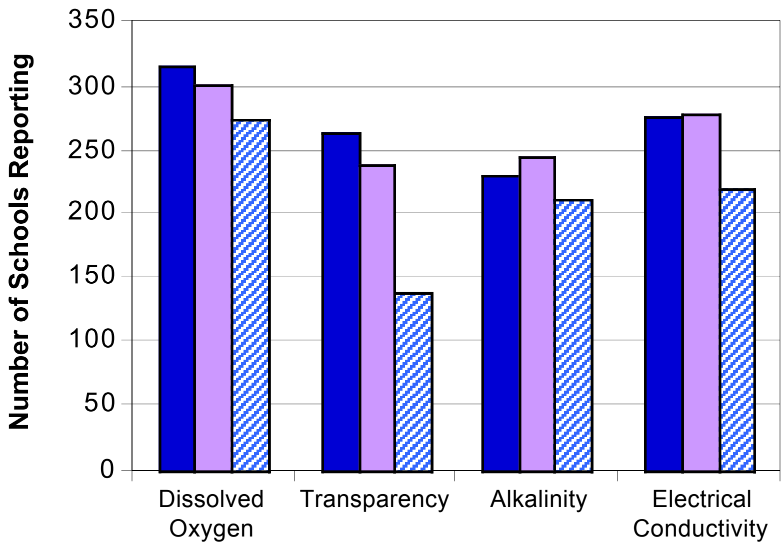
Figure 3.11a
Number of Schools Reporting Hydrology Data in 1999-2000,
by Reporting Duration Category



	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
> 6 mos	108	146	153	151	148	150	158	148	142	95	54	47
3-6 mos	60	78	92	68	72	79	90	73	74	31	12	19
< 3 mos	25	31	19	17	9	16	19	27	19	10	7	9

Teachers continue to report in their surveys that locating and arranging for transportation to a suitable water site are significant challenges that cannot always be met. However, the teachers who have overcome this barrier are reporting implementation of a wider set of Hydrology protocols, including newer protocols such as Dissolved Oxygen, Transparency, Electrical Conductivity, and Alkalinity. (See Chapter 4, for a discussion of implementation patterns reported on the teacher survey and Table 4.14.) The significant increase in the proportion of trained teachers in Year 5 who report implementing the newer Hydrology protocols (as compared with trained teachers in Year 3) is borne out to some extent in the numbers of schools reporting these types of water quality measurements, as shown in Figure 3.12. Moreover, from teacher comments, it seems that a number of schools are implementing protocols and learning activities in investigation areas like Hydrology without actually submitting their measurements to the Student Data Archive. (This issue will be discussed at some length in Chapter 4.)

Figure 3.12
Number of Schools Reporting Selected Hydrology Protocols, by Year

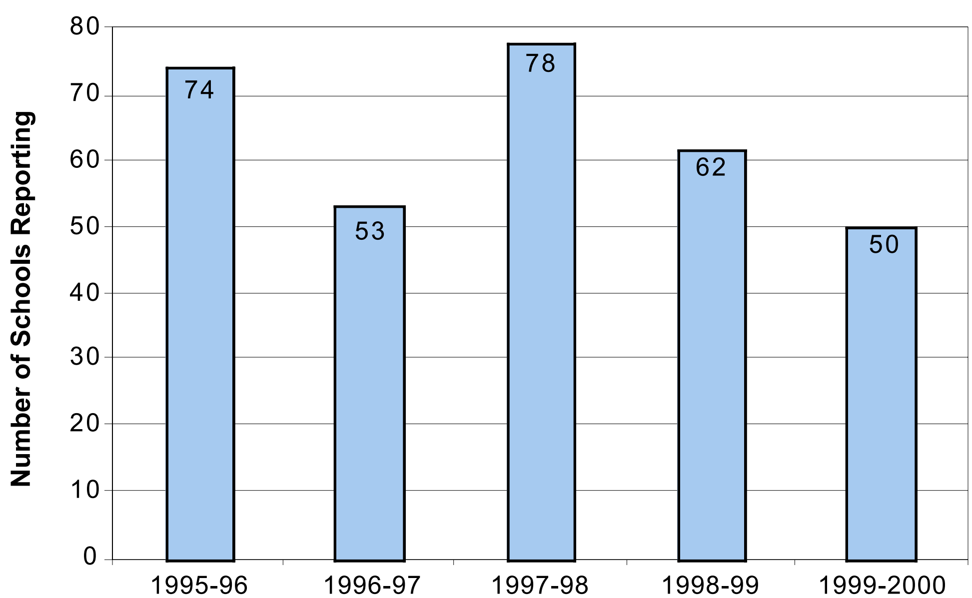


	Dissolved Oxygen	Transparency	Alkalinity	Electrical Conductivity
1999-2000	315	264	228	277
1998-99	302	239	245	279
1997-98	275	137	211	218

In Figures 3.13 through 3.16, we show the number of schools reporting measurements expected to be taken less frequently (i.e., Soil and Land Cover/Biology). Soil Moisture is now generally conducted on a monthly basis. Soil Characterization, Biometry, and Land Cover protocols are conducted on a seasonal or annual basis.

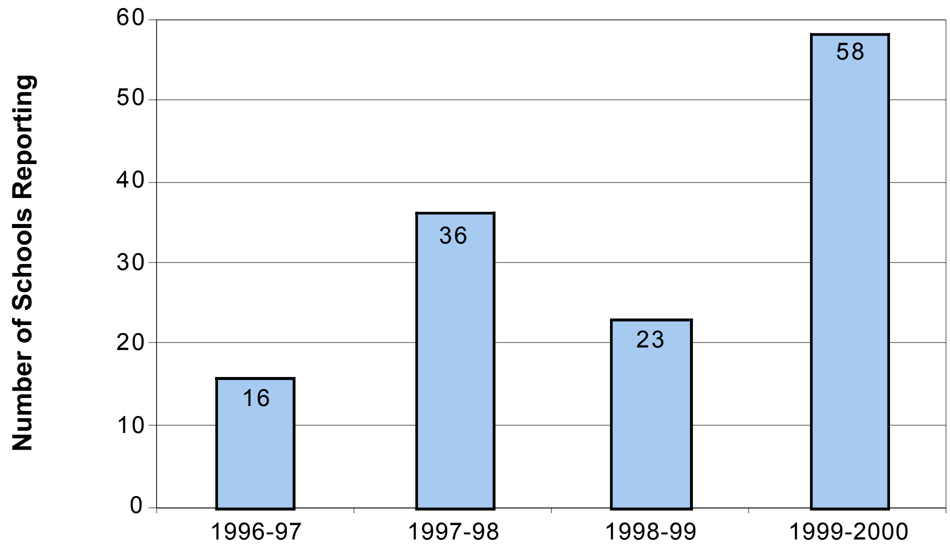
Soil Moisture reports continue to follow a seasonal pattern and to be reported by relatively few schools (see Figure 3.13). As with Hydrology, the protocol frequency requirement for Soil Moisture has undergone a change. Requested frequency was reduced from daily to semiannually when GLOBE II protocols were instituted (fall 1997), thus obscuring the interpretation of trends in reporting numbers across years. An additional complication is that schools that have maintained the use of the advanced Gypsum Block method continue to report on a daily basis. On our survey, about one-third of teachers at schools reporting that they implement Soil Moisture protocols responded that they use the Gypsum Block protocol.

Figure 3.13
Number of Schools Reporting Soil Moisture Data, by Year



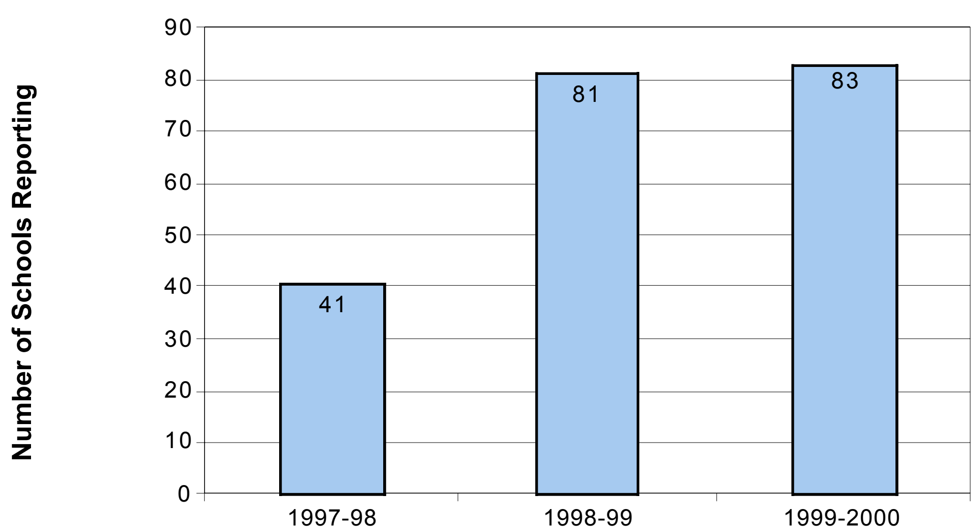
Although still infrequent in terms of absolute use, the number of schools reporting Soil Characterization data has more than doubled from just 23 in 1998-99 to 58 in 1999-2000, as shown in Figure 3.14.

Figure 3.14
Number of Schools Reporting Soil Characterization Data, by Year



The Soil Temperature protocol requests measurements on a weekly basis. The number of schools reporting this measurement rose from 41 to 81 between 1997-98 and 1998-99; there was no real additional growth during the 1999-2000 school year (see Figure 3.15). One school in Germany takes daily Soil Temperature measurements for

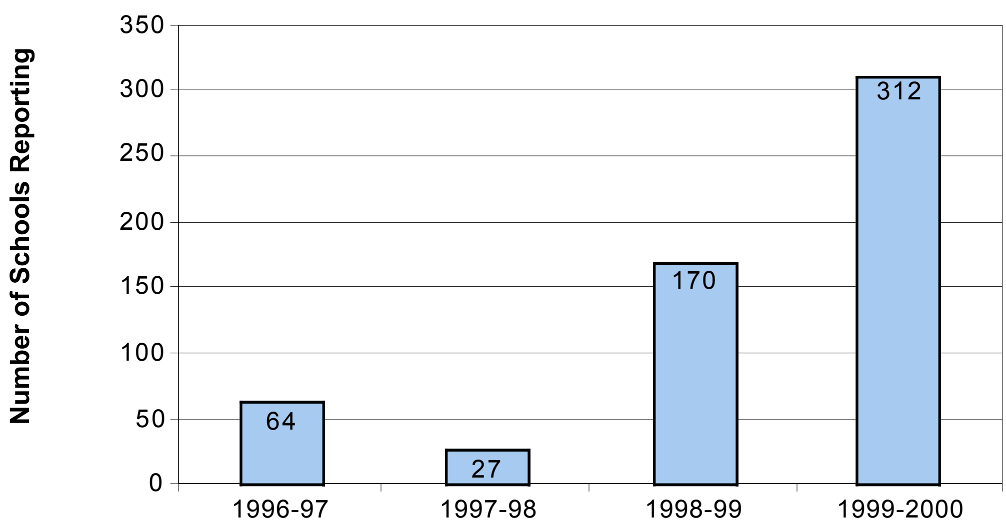
Figure 3.15
Number of Schools Reporting Soil Temperature Data, by Year



multiple sites and submitted more than 8,000 of the 19,131 Soil Temperature measurements sent to the GLOBE data archive between September 1999 and August 2000. The fact that the various types of Soil protocols have such different reporting patterns suggests that teachers are considering them individually rather than as an integrated unit.

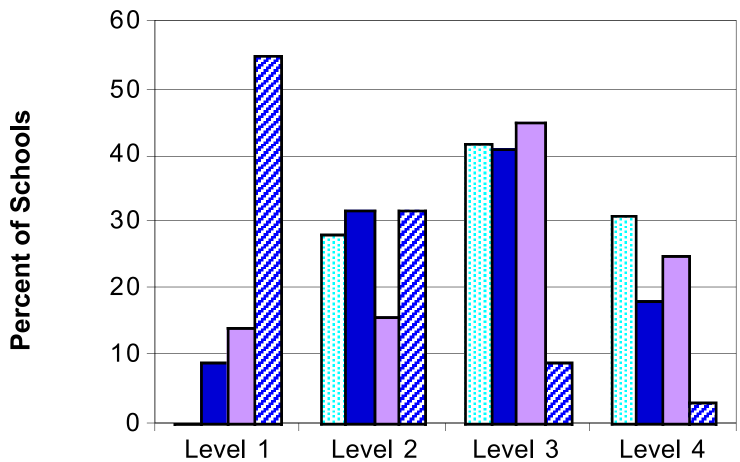
The Land Cover Qualitative data protocol, where students classify and assign land cover codes according to the Modified UNESCO Classification system (MUC), continues to experience an increase in the number of schools reporting data, as shown in Figure 3.16. More than 1,000 MUC reports were made by 312 schools during the period September 1999 to August 2000, a three-fold increase in reports and an almost 100% increase in the number of schools over the same period a year ago.

Figure 3.16
Number of Schools Reporting Land Cover Qualitative Data, by Year



"MUC-a-thons" have been held in several communities in the United States and internationally where schools lay out land cover pixel sites in as many places in their communities as they can access over a weekend and work on ground-truthing satellite data for those sites. At the First International GLOBE Land Cover Symposium held in Croatia in October of 1999, students learned about remote sensing, practiced Land Cover protocols, and heard scientists discuss the importance of the data students have collected and how it is put to practical use in their scientific work. In addition to the fact that more schools are reporting more Land Cover Qualitative data, there has been an increase in the depth of students' classifications. Over the last three years, there has been a steady increase in the number of reports that have classified sites to Level 3 and 4 classifications, as shown in Figure 3.17.

Figure 3.17
Distribution of MUC Levels Reported in 1996-2000

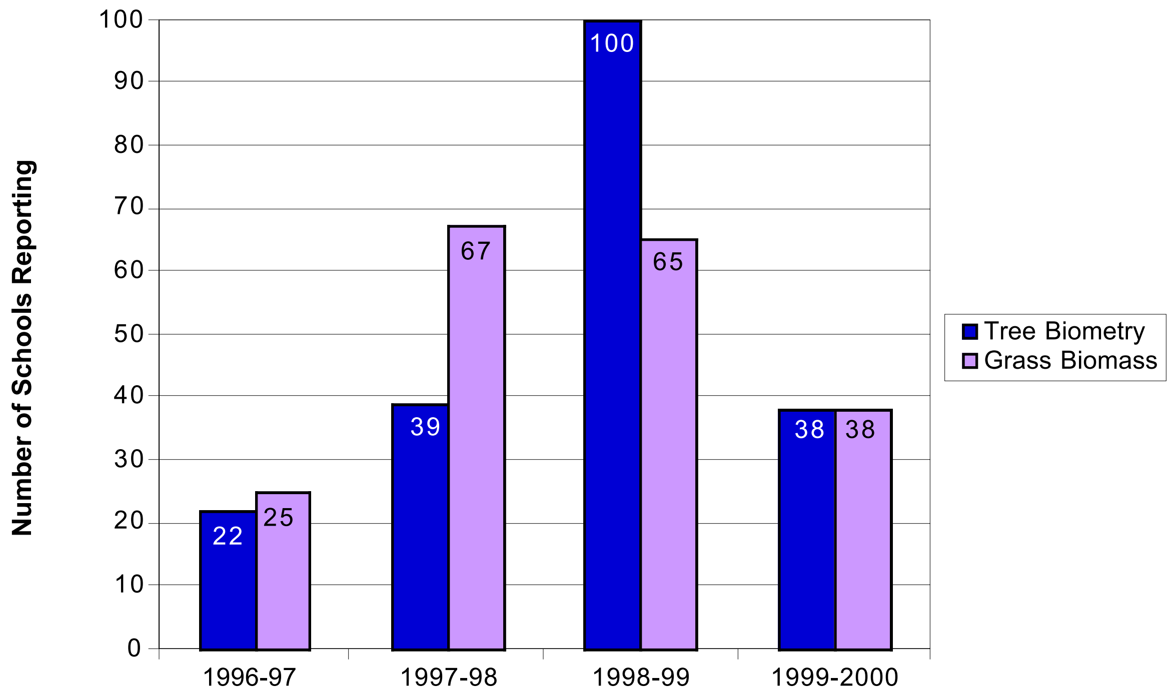


	Level 1	Level 2	Level 3	Level 4
1999-2000	0	28	42	31
1998-99	9	32	41	18
1997-98	14	16	45	25
1996-97	55	32	9	3

Note: Some types of land cover can be classified only to Level 2 and a few others only to Level 3.

There has been a decrease in the number of schools reporting Quantitative Land Cover/Biometry data during 1999-2000 (see Figure 3.18). The number of schools dropped from a high of 100 schools reporting tree biometry data down to 38 schools. Many of these same 38 schools also reported grass biometry data. It is notable that most of the international schools reporting these types of data were from Norway, Finland, Estonia, and the Czech Republic, and it is likely that there were schools that participated in the joint GLOBE expedition held in spring 2000.

Figure 3.18
Number of Schools Reporting GLOBE II
Quantitative Land Cover/Biometry Data, by Year

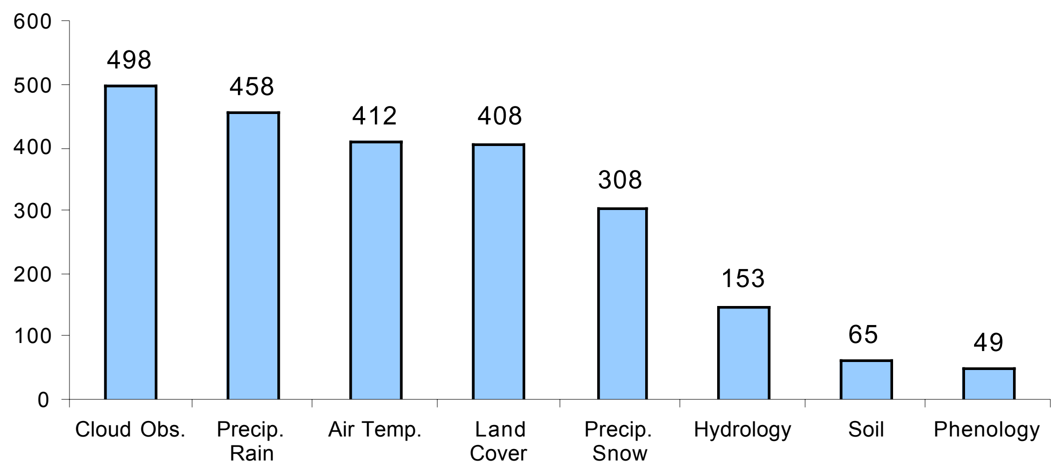


Reports of Metadata

Analysis of metadata comments submitted along with data reports during 1999-2000 shows that the majority of schools submitting metadata do so for protocols within the Atmosphere and Land Cover investigation areas. Figure 3.19 shows the number of schools that reported one or more pieces of metadata for each of the four most common Atmosphere protocols and for Hydrology, Land Cover, Soil, and Earth as a System (Phenology) investigation areas. Between 400 and 500 schools reported metadata for the Atmosphere Cloud Observation, Precipitation Rain, and Air Temperature protocols, and over 400 schools reported Land Cover metadata.

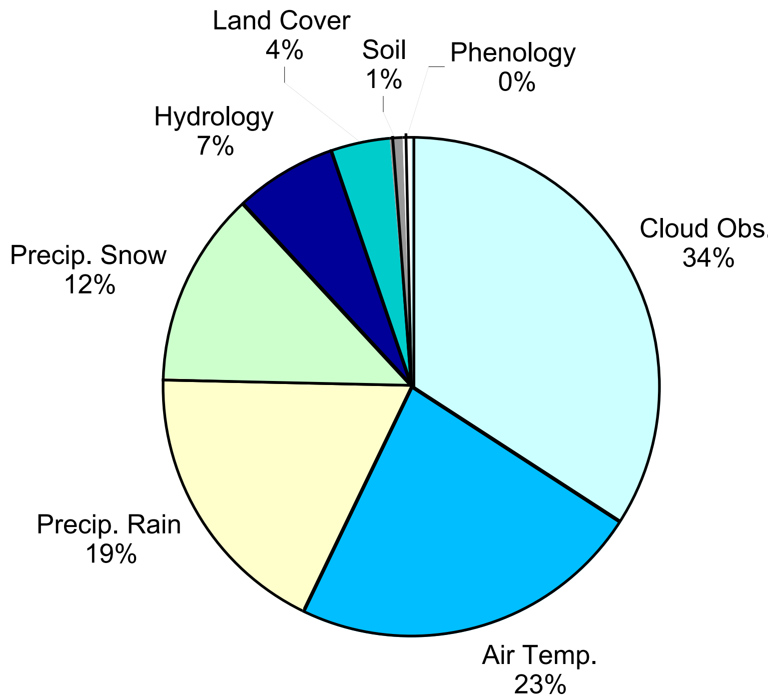
Many of the metadata comments that have been submitted can be scientifically useful, such as "Hurricane Floyd caused a sewage overflow into the Creek. Oil splotches have been reported. EPA investigating." A small number of schools report the name of the student that actually submitted the measurement—perhaps as a way to help students feel ownership of data reporting responsibility. Some schools report details on the type of instruments used (if different from those recommended in the GLOBE protocols) and additional measurements not currently included in the program such as phosphate levels in surface water samples. Many schools have submitted observations about the weather, flora, and fauna found in the measurement site area and descriptions of the current condition of the site.

Figure 3.19
Number of Schools Reporting Metadata
September 1999 through August 2000



Another way to look at metadata reporting is in terms of the number of comments submitted. Figure 3.20 shows the 1999-2000 metadata reports classified by protocol or investigation area. (For purposes of this analysis, notations stating "Phase 1 (or 2) data entry via e-mail" in measurement comments fields have not been included in the counts.) Not surprisingly, Cloud Observation—the most frequently reported GLOBE measurement—accounts for over one-third of the 17,183 metadata comments submitted during the 1999-2000 school year.

Figure 3.20
Number of Metadata Reports, by Protocol/Area
September 1999 through August 2000



Effects of Multiple Teachers per School on Reporting Patterns

In Year 4, we found some indication of a greater likelihood that a school will report data and report more types of data if the school has more than one teacher trained in GLOBE. In Year 4, 32% of U.S. GLOBE schools with more than one teacher trained reported data compared with 14% of U.S. schools with only one teacher trained. Similarly, in Year 5, 21% of the 2,040 U.S. schools with more than one teacher trained reported data compared with 12% of U.S. schools with only one teacher trained. International schools showed the same pattern but with a higher proportion of schools reporting data. Forty-three percent of international schools with more than one teacher trained and 33% of international schools with one teacher trained reporting data during Year 5.

In terms of the number of different types of measurements reported, Year 5 data do not show the higher-reporting advantage for schools with multiple GLOBE teachers that was seen in Year 4. Both U.S. and international schools reported an average of 3.9 types of data, and there is very little difference between the average number of data types for schools with more than one teacher trained and that for schools with only one trained teacher. This lack of reporting advantage for schools with multiple GLOBE-trained teachers in terms of diversity of submissions to the Student Data Archive contrasts with the teacher reports of the range of protocols implemented at their school (further discussed in Chapter 4).

Discussion

These analyses of Year 5 GLOBE data reporting patterns suggest modest but widespread increases in the number of schools reporting data and the duration of their data collection. Given the dip in data reporting in Year 4, the 1999-2000 record is heartening. The participation rate for Land Cover Qualitative and the increased reporting of Soil Characterization data were particularly promising signs. Nevertheless, the program remains more successful in scaling up its teacher training activities (which rose 15% over Year 4) than in scaling up data reporting (which experienced a 10% increase in number of schools reporting from Year 4 to Year 5). The next chapter discusses some of the barriers that GLOBE-trained teachers suggest inhibit program implementation.

Chapter 4. Characteristics and Implementation at the Local Level

This chapter describes characteristics of local GLOBE programs by examining data from the 1,033 teachers who responded to our survey regarding teacher participation in GLOBE activities during the 1999-2000 school year. As discussed in Chapter 2, our survey data for the Year 5 evaluation comes from two main samples: (1) recently trained U.S. teachers and (2) teachers from schools actively reporting GLOBE data, both U.S. and international. The first of these two samples was drawn from the population of U.S. teachers who received their GLOBE training between June 1998 and August 1999. This sample was defined and selected in the same way as the sample of U.S. teachers trained between June 1996 and August 1997 who were surveyed in the spring of 1998 (Year 3 of the GLOBE Evaluation), and comparisons between the two groups are made throughout this chapter.

The second sample was drawn from the population of GLOBE schools that actively report data. This sample represents schools that contributed an above-average quantity of environmental data to the GLOBE Student Data Archive in the winter of 1999-2000. For each such school in the sample, we asked that the most active GLOBE teacher at the school complete the survey.[1] Teachers were included in this second sample without regard to the time when they received their GLOBE training. The same criterion for classification as "active" was applied to both U.S. and non-U.S. schools.[2] The data we get from teachers at schools actively submitting GLOBE measurements provide us with a portrait of more mature, fuller GLOBE implementations. For the most part, survey responses from U.S. and international teachers in active GLOBE programs are pooled. When there are major differences in implementation patterns, however, we report findings for U.S. and international teachers separately.

All survey respondents answered basic questions concerning the nature of their training and the influence of that training on their subsequent teaching. Those respondents who indicated that they had implemented GLOBE with students during the 1999-2000 school year completed a second, more detailed section of the survey containing questions concerning the nature of their GLOBE activities. The bulk of the

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[1] For each of the active schools we sampled that had more than one GLOBE teacher, we requested that the most active of the GLOBE teachers at that school fill out the survey. In previous evaluation reports, we referred to these teachers as "Active Data Providers," or ADPs. See Chapter 2 for a more thorough discussion of the different groups of GLOBE teachers we sampled.

[2] An analysis of when teachers in our active sample received their GLOBE training revealed that 43% of this sample was trained in the same June 1998 through August 1999 time frame as the "recently trained teacher" sample. The remainder were trained in earlier years, some as long ago as 1995.

data in this chapter are derived from these latter teachers, 254 in the trained teacher sample and 485 active teachers.

Throughout the rest of this chapter, we refer to the main two samples as “trained” (or “recently trained”) and “active” (or “total active”) teachers. We have organized our reporting of survey findings by topic (e.g., protocol implementation), with responses from both survey samples described for each topic. We begin each section of the chapter with a description and comparison of the data from each of our two main samples for the Year 5 survey. In tables containing data from the two Year 5 samples, those differences between trained and active teacher samples that are statistically significant are denoted by an asterisk next to the higher of the two values. We report our findings under the heading “Current Practices.” Then, in cases where the same question was asked in 1998 and 2000, we compare the data from our U.S. “trained” sample in Year 5 with survey data collected in Year 3 from U.S. teachers trained in 1997-98. This comparison of teachers from analogous samples collected in different years is reported under the heading “Trends.” (Statistically significant differences between analogous samples from the two years are denoted by an asterisk.) In this way, we seek to provide both a snapshot of the program as it was implemented by active schools (the Year 5 active sample) and by newer GLOBE schools (the Year 5 recently trained sample) in 1999-2000 and an indication of ways in which the program is evolving (the trends comparing typical implementations of recently trained teachers in Year 5 and Year 3).

Training Outcomes

With its involvement of scientists as well as science educators and GLOBE’s strong emphasis on scientific investigation, GLOBE training can potentially influence teachers in many positive ways even if the teachers who undergo training do not implement the GLOBE Program per se within their schools. All survey respondents were asked to indicate ways in which their GLOBE training has influenced their practice. Potential influences, as enumerated in item A.5 of the survey (shown in Appendix A) range from using GLOBE materials to teach core curriculum topics and introducing more observation and measurement into science instruction to merely incorporating some GLOBE-related explanations.

Current Practices

When asked about the effects that GLOBE training had on their classroom teaching practices, nearly every survey respondent (99.5% of active teachers and 97% of recently trained teachers) reported one or more changes in practice. Table 4.1 shows the proportion of respondents saying that GLOBE training influenced their practice to varying degrees in each of the ways probed by the survey item.

Table 4.1
Influence of GLOBE Training on Teacher Classroom Practices, as Reported by Year 5 Trained and Active Teachers
(Percent Reporting)

	Trained			Active		
Change in Teaching Practices	**None**	**Some**	**Major**	**None**	**Some**	**Major**
Used some GLOBE-related explanations and examples in my teaching	10*	50	40	2	33	65*
Gave more emphasis to observation and measurements	12*	38	50	2	24	74*
Introduced new topics based on GLOBE into my curriculum	20*	46	34	6	33	61*
Gave more emphasis to data analysis	14*	44	42	3	38	59*
Incorporated more hands-on science activities	14*	42	44	6	35	59*
Used GLOBE material to teach topics I was teaching before with other materials	15*	48	37	6	39	55*
Had students use Web-based science resources	30*	42	28	8	42	50*
Had students design and conduct science investigations	21*	49	30	13	48	39*
Sample sizes:	51 ≤ n ≤ 143	195 ≤ n ≤ 245	165 ≤ n ≤ 241	8 ≤ n ≤ 62	118 ≤ n ≤ 236	194 ≤ n ≤ 369

Note: Respondents used a five-point scale ranging from “Not at All” to “Great Extent.” The highest two points on the scale were summed and are shown here as “Major.” Responses indicating the second and third points on the scale are summed and shown as “Some.”

*Difference between trained and active respondents significant at $p < .05$

Active teachers reported that GLOBE training had a larger influence on their subsequent practice than did recently trained teachers, but the great majority of teachers in both groups cited some influence in each of the areas we probed. The greatest influence of GLOBE training on teachers’ science instruction appears to be an increased emphasis on incorporating observations and measurements in their science activities. On our five-point scale, 74% of active teachers and 50% of recently trained teachers selected the highest or second highest value for this influence. The second, third, and fourth strongest influences on practice differed for the two samples. Among active teachers, the use of GLOBE-related explanations and examples was the second most common strong influence (at 65%), followed by the introduction of new curriculum topics based on GLOBE (61%) and then incorporation of more hands-on science activities and increased emphasis on data analysis (both at 59%). Among recently trained teachers, the second most commonly cited major influence was the incorporation of more hands-on activities (44%), followed by more emphasis on data analysis (42%) and use of some GLOBE-related explanations (40%). Many of the kinds of changes teachers said they made as a result of their GLOBE training (e.g., more hands-on science, data analysis, and student design and conducting of investigations) are consistent with the science education teaching standards advocated by the National Research Council (NRC, 1996).

Teacher Participation in the GLOBE Program

Current Practices

Among the teachers in the “active” sample of our survey, 97% said that they were involved in the GLOBE Program in the year 1999-2000. Nearly all of these involved teachers (98%) reported using GLOBE with students during this time. Since the sample represents schools actively reporting GLOBE data, these high participation rates are no surprise. In addition to implementing GLOBE with students, teachers in our active sample reported being involved in data reporting, training new teachers, or coordinating GLOBE implementation in their school.

In contrast, the teachers sampled from the population of June 1998 through August 1999 trainees were far less likely to say they were involved in the GLOBE Program in the school year 1999-2000. However, more than half (57%) reported being involved with GLOBE during the 1999-2000 school year. Among recently trained teachers reporting that they were involved with GLOBE in some way, 87% used some aspect of the program with students during 1999-2000. Other forms of involvement cited by recently trained teachers not using GLOBE with students included participation in training, supporting other teachers, engaging in Web chat, and keeping up with GLOBE news.

Table 4.2 shows the barriers that recently trained teachers who did not implement GLOBE cited as impediments. The most serious barriers cited by teachers who did not implement the program concern time requirements: time to prepare, collecting data on the weekends, completing activities within the school schedule, and taking time away from mandated material. The perceived seriousness of these barriers are similar across grade levels. The only barrier for which there is a significant difference is completing GLOBE within the school schedule.

Table 4.2
Problems Rated as "Major Barriers" by Elementary, Middle/Jr. High, and High School Trained Teachers Not Implementing GLOBE with Students

Barrier Rated as "Major"	*Elem. School*	*Middle/ Jr. High*	*High School*
Difficulty finding time to prepare	57	47	48
Lack of way to collect data on weekends	52	46	39
Difficulty completing activities within school schedule	58*	35	33
Time away from mandated material	46	37	47
Difficulty integrating GLOBE into curriculum	37	37	38
Difficulty identifying appropriate site to take measurements	17	30	35
Lack of Internet access	19	19	26
Lack of computer hardware/software	16	16	26
Lack of tech support	15	20	21
Concern if GLOBE is valuable for students	7	0	12
Sample sizes:	$90 \le n \le 92$	$60 \le n \le 63$	$51 \le n \le 56$

* Differences among grade levels significant at $p < .05$

For both the active and the trained teacher samples, data regarding implementation of the program were collected from those teachers responding that they were involved in implementing some aspect of the program with students. As indicated above, this chapter is primarily based on the responses of these teachers.

Trends

The percentage of recently trained teachers reporting that they implemented GLOBE with students decreased somewhat between 1998 and 2000. In Year 3, 65% of teachers in our trained teacher sample had used the program with students compared to 50% of recently trained teachers in the Year 5 survey.[3]

[3] We ran analyses comparing the Year 3 and Year 5 recently trained teacher samples in terms of grade level taught and the time elapsed between training and survey. The two samples did not differ in terms of the proportion teaching at the three grade levels (elementary, middle, secondary). Members of the Year 5 sample were more likely than those in the Year 3 sample (46% versus 33%) to have more months elapsed between their training and the survey period.

In both survey years, trained teachers who had not implemented GLOBE with students responded to a survey question about barriers that stood in the way of implementation. As shown in Table 4.3, trained teachers have reported similar barriers to using GLOBE over time. There are a few differences, however; lack of Internet access is no longer among the most frequently cited barriers, and a smaller proportion of teachers cite lack of access to either the Internet or to computers as a major barrier. Finding time to prepare to implement GLOBE remains a frequently reported impediment, and other aspects of time limitations (such as the inability to collect weekend data, school schedule constraints) continue to weigh on teachers' minds. Forty-three percent of GLOBE-trained teachers who were not implementing the program with students cited the time that GLOBE would take away from mandated materials as a major barrier. The two barriers which have increased in reported frequency since Year 3 are "integrating GLOBE into the curriculum" and "concern if GLOBE is valuable for students." Although this latter concern has become more common, it remains the least frequently cited of the barriers rated by teachers.

Table 4.3
Problems Rated as "Major Barriers" by Trained Teachers Not Implementing GLOBE with Students

Barrier Rated as "Major"	*Y3 Trained*	*Y5 Trained*
Difficulty finding time to prepare	46	52
Lack of way to collect data on weekends	52	47
Difficulty completing activities within school schedule	42	44
Time away from mandated material	N/A	43
Difficulty integrating GLOBE into curriculum	34	37*
Difficulty identifying appropriate site to take measurements	25	27
Lack of Internet access	49*	21
Lack of computer hardware/software	31*	19
Lack of tech support	21	17
Concern if GLOBE is valuable for students	4	6*
Sample sizes:	$108 \leq n \leq 117$	$223 \leq n \leq 231$

* Differences between Y3 and Y5 respondents significant at $p < .05$

School Implementation Patterns

Current Practices

Overall, roughly half of U.S. GLOBE implementations are done with elementary school students while the other half are done with middle or high school students. Within elementary schools, GLOBE is typically offered within a general elementary classroom rather than in a class or club taught by a science teacher. (See Table 4.4.) An implication of this fact, as noted in the Year 3 report, is that GLOBE teachers at the elementary level do not necessarily come to the program with a strong science background.

As shown in Table 4.4, GLOBE is more likely to be implemented at the elementary school level in the United States than in international schools. Among active programs, 50% are at the elementary level in the United States compared to 8% internationally. Another important difference is the extent to which GLOBE is treated as a part of a regular science class as opposed to a club or special pull-out program. As shown in Table 4.4, club and pull-out programs at the high school level constitute 31% of active international programs compared to 9% within the United States.

In middle and secondary schools in the United States, GLOBE was most commonly incorporated into standard science classes,[4] including general/integrated science, environmental/ecological science, Earth/space/physical science, and biology/life science. Internationally, middle and high school level GLOBE programs are equally likely to be regular classes or club and pull-out programs. Table 4.5 presents percentages for the combined sample of the types of middle and secondary school classes in which GLOBE is taught. At the middle school level, GLOBE is most frequently implemented as part of a general or integrated science class. The type of high school class most likely to include GLOBE is environmental or ecological science.

Another element of implementation tracked in our surveys is whether GLOBE is used by a single teacher or a team of teachers within a school. Teacher responses to the Year 5 survey showed a difference between our two teacher samples in the number of teachers implementing GLOBE at their schools. Teachers drawn from the population of recent GLOBE U.S. trainees were more likely than teachers in the active U.S. school sample to have one or more GLOBE-trained colleagues at their school (60% v. 44%). Recently trained U.S. teachers were also more than twice as likely as active U.S. teachers to be in a group of three or more trained GLOBE teachers at their school (29% v. 12%).

[4] These findings are based upon text responses to a question asking for the class title of the regular middle or secondary course in which GLOBE was taught. About half the respondents (123 out of 274) who answered that GLOBE was taught in a regular class also gave the specific title.

Table 4.4
Teacher Reports of Setting Within Which GLOBE is Implemented
(Percent Reporting)

Setting	Year 5 U.S. Trained			Year 5 U.S. Active			Year 5 Int'l Active			Year 5 Overall Sample		
	Elem	Mid	High	Elem	Mid	High	Elem	Mid	High	Elem	Mid	High
Comprehensive elementary class	71	4	0	61	1	0	50	17	2	64	6	1
Elementary science class	11	1	0	15	6	0	0	2	2	14	3	1
Elementary lunch or club	4	0	0	9	0	0	25	6	4	8	2	1
Other elementary	11	1	3	13	4	1	25	2	2	13	3	2
Regular middle or high school class	2	79	74	1	70	85	0	35	42	1	64	70
Middle or high school pull-out program	0	1	11	1	6	5	0	6	17	<1	5	10
Middle or high school lunch or club	1	13	12	0	13	9	0	31	31	<1	18	16
Sample sizes:	n = 108	n = 70	n = 66	n = 163	n = 83	n = 80	n = 8	n = 48	n = 48	n = 268	n = 196	n = 180

Table 4.5
Middle and Secondary School Classes in Which GLOBE is Taught
(Percent Reporting)

Subject Areas	***Middle***	***Secondary***
General/Integrated Science	52	13
Environmental/Ecological Science	2	40
Earth/Space/Physical Science	19	19
Biology/Life Science	6	14
Other subject areas (Math/Science, Chemistry, Issues in Science, Computer Science, Geography, ESL Social Studies)	13	8
Other Classes		
Dedicated GLOBE classes (study hall, homeroom, science lab, atmosphere)	4	
Gifted students classes	4	2

The data also revealed country differences in GLOBE staffing patterns. Among active teachers, those from schools outside the United States were somewhat more likely than their American counterparts to have another GLOBE teacher at their school (54% v. 44%) and almost twice as likely to be in a group of three or more teachers (22% v. 12%). Table 4.6 shows the number of teachers per school for the samples represented in the 2000 survey.

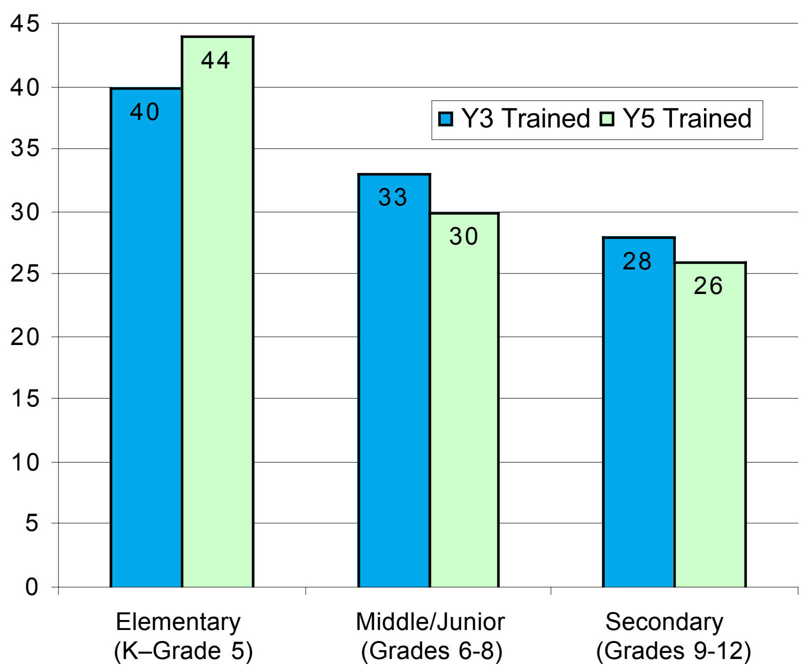
Table 4.6
Number of GLOBE Teachers per School
(Percent Reporting)

Number of GLOBE Teachers at School	***U.S. Trained***	***U.S. Active***	***International Active***	***Total Active***
One	39	54	45	46
Two	31	32	32	32
Three or more	29	12	22	23
Sample sizes:	n = 283	n = 349	n = 124	n = 473

Trends

As shown in Figure 4.1, the grade level at which teachers are implementing the GLOBE Program in the United States appears to be shifting slightly to the younger grades since the Year 3 survey was conducted in 1998. In Year 3, more than one-third of U.S. GLOBE teachers implemented the program at the elementary level (40%), one-third at the middle school or junior high level (33%), and nearly one-third at the high school level (28%).[5] In Year 5, 44% of recently trained teachers implemented the program at the elementary level, 30% implemented at the middle school or junior high level, and only 26% implemented at the high school level. This increase in the proportion of recently trained teachers who work at the elementary level is not statistically significant. The 2000 figures for teachers at active U.S. schools also indicate a preponderance of elementary level programs: 50% at the elementary level, 26% at the junior high level, and 24% at the high school level. Nationally, about 35% of K-12 teachers work at the elementary level (NCES, 1997). It may be that self-contained elementary programs, with their greater flexibility in terms of time and curriculum requirements, are viewed as more compatible with the logistical requirements of implementing GLOBE.

Figure 4.1
Educational Levels at Which
GLOBE is Implemented, Year 3 and Year 5 Trained Teachers



Sample sizes: Y3 = 193, Y5 = 465

[5] For this analysis, teachers who worked with students in grades 6-8 are included in the middle school/junior high level regardless of their school's name or designation.

Another difference between implementation contexts reported by U.S. trained teachers in Years 3 and 5 is that GLOBE is now more commonly taught in biological or life science at the middle and high school levels (3% and 14% for Years 3 and 5, respectively). This trend is accompanied by an increase in the frequency with which protocols and learning activities most relevant to biological science are being implemented, particularly Land Cover/Biology. (See discussion of protocol implementation later in this chapter and in Chapter 3.) Responses to our Year 5 survey also indicate that certain settings that have been less common, such as dedicated GLOBE classes, classes for special or gifted populations, and cross-age groupings at the elementary level, are on the rise as contexts for implementing GLOBE.

The trend noted in Year 3 toward having more U.S. GLOBE programs conducted by multiple GLOBE teachers rather than a solo practitioner continued in Year 5. Just 39% of recently trained teachers in the Year 5 survey reported being the only GLOBE trainee at their schools. In 1998, more than 50% of surveyed teachers reported that they were the only teacher implementing the GLOBE Program at their schools. In the 1996 survey, 72% of respondents identified themselves as the only GLOBE teacher at their schools. Thus, it appears that more schools are thinking of GLOBE as a multi-teacher undertaking and that, compared to 1998, a larger proportion of recently trained teachers are the second or third, rather than the first, GLOBE trainee at their schools.

Teacher Time Devoted to GLOBE

Current Practices

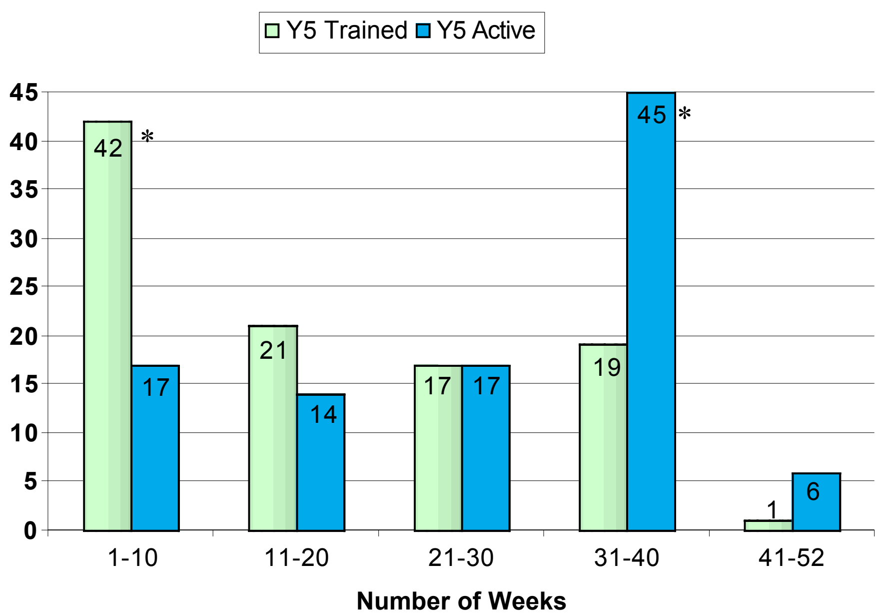
To get a sense of GLOBE's prominence within science education as well as of the feasibility of obtaining scientifically useful data sets from the program, we asked GLOBE teachers to indicate the number of weeks during the year in which they involved their classes in GLOBE activities. Figure 4.2 shows teacher responses grouped in 10-week increments. As is readily apparent from the figure, active teachers were far more likely than trained teachers to implement GLOBE for most of the school year (51% and 20%, respectively, indicated more than 30 weeks) and trained teachers were far more likely than active teachers to implement for a relatively small part of the year (42% and 17%, respectively, indicated that they use GLOBE for 10 weeks or less).

On average, active teachers implemented GLOBE for 27 weeks—close to the length of a full academic year. In contrast, recently trained teachers spent an average of 16 weeks implementing GLOBE with students. However, despite the short involvement with GLOBE activities that many recently trained teachers provided for their students, there was a core of close to 20% of these teachers who reported spending more than 30 weeks on GLOBE implementation.

The intensity of GLOBE implementation is, of course, a function not just of the numbers of weeks' duration but also of the amount of time spent on the program each week. In Year 5, active teachers reported spending on average 2.2 hours per week working on GLOBE with students in their single most active class. With an average program duration of 27 weeks, this constitutes giving their students 59 hours of exposure to GLOBE each year. Recently trained teachers who implemented GLOBE with students reported spending 2.0 hours per week on implementation, just slightly less time than active teachers. With an average implementation duration of 16 weeks, it appears that typical recently trained teachers who implemented GLOBE in the school year following their training provided their students with 32 hours of exposure to the program.

We also asked teachers how much time they need to spend preparing for GLOBE each week. Although active teachers spent slightly more class time per week implementing GLOBE with students, they reported spending only 1.2 hours per week preparing for GLOBE activities with their most active class, compared to the 1.7 hours reported by recently trained teachers.

Figure 4.2
Duration of GLOBE Implementation,
by Trained and Active Teachers in Year 5



Sample sizes: Trained n = 230, Active n = 451

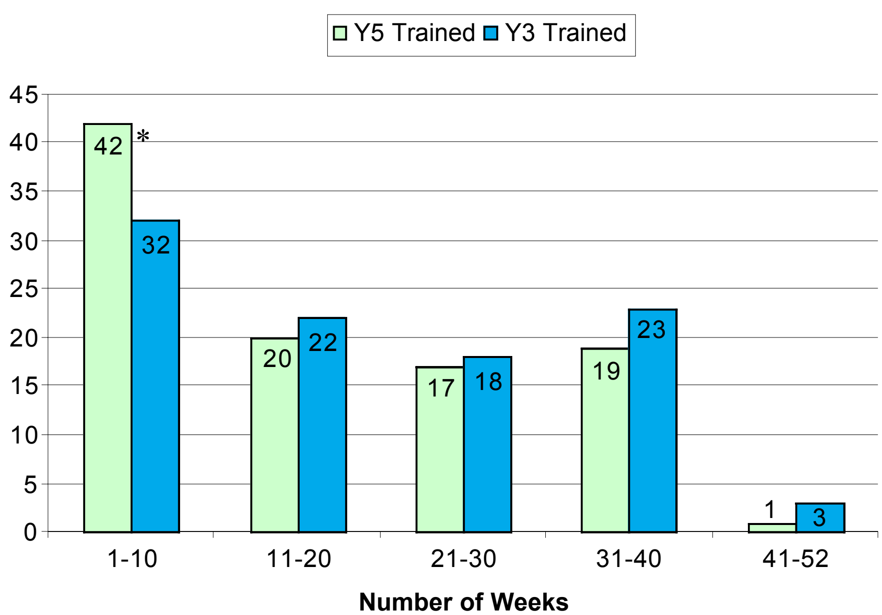
*Difference between trained and active respondents significant at p < .05

Trends

Figure 4.3 shows a comparison between the number of weeks recently trained GLOBE teachers reported spending on GLOBE in Year 3 and Year 5. As is shown, a larger proportion of recently trained teachers reported implementing GLOBE for a short duration (10 weeks or less) in Year 5 than in Year 3. The percentage of trained teachers implementing GLOBE who are devoting more than 30 weeks to the program has decreased from 26% to 20%. While in Year 3 trained teachers spent on average 22 weeks implementing the program, trained teachers in Year 5 spent on average only 16 weeks.

In Year 3, recently trained teachers implementing GLOBE reported spending an average of 2.4 hours per week on this program in their single most active class. This figure is just modestly higher than the 2.0 hours per week reported by recently trained teachers in Year 5. However, when the hours per week and number of weeks of implementation are combined, the average GLOBE experience received by students of recently trained teachers who choose to implement GLOBE has dropped from 53 to 32 hours a year.

Figure 4.3
Duration of GLOBE Implementation,
by Trained Teachers in Year 3 and Year 5



Sample sizes: Y3 Trained n = 176, Y5 Trained n = 230

*Difference between Y3 and Y5 respondents significant at $p < .05$

The decrease in total amount of time a recently trained teacher is spending doing GLOBE activities with his or her students is open to multiple interpretations. It is clear from responses to other survey items (to be discussed below) that many teachers are feeling increasing pressure to devote time to teaching material related to state or local curriculum standards, many of which may not coincide with GLOBE content. On the other hand, it appears that more teachers in a given school are implementing GLOBE activities with students, and thus, while the exposure to GLOBE provided by an individual teacher may be declining, the total amount of GLOBE experience students receive when multiple teachers are involved in GLOBE may be the same or even higher. This distinction between what is implemented by an individual teacher and what is implemented by a school as a whole will be discussed later in this chapter.

Findings from Year 5 also suggest a decrease in the amount of time teachers spend preparing for GLOBE activities each week. Trained teachers reported spending 1.7 hours of preparation time in Year 5 compared to 2.2 hours per week in Year 3.

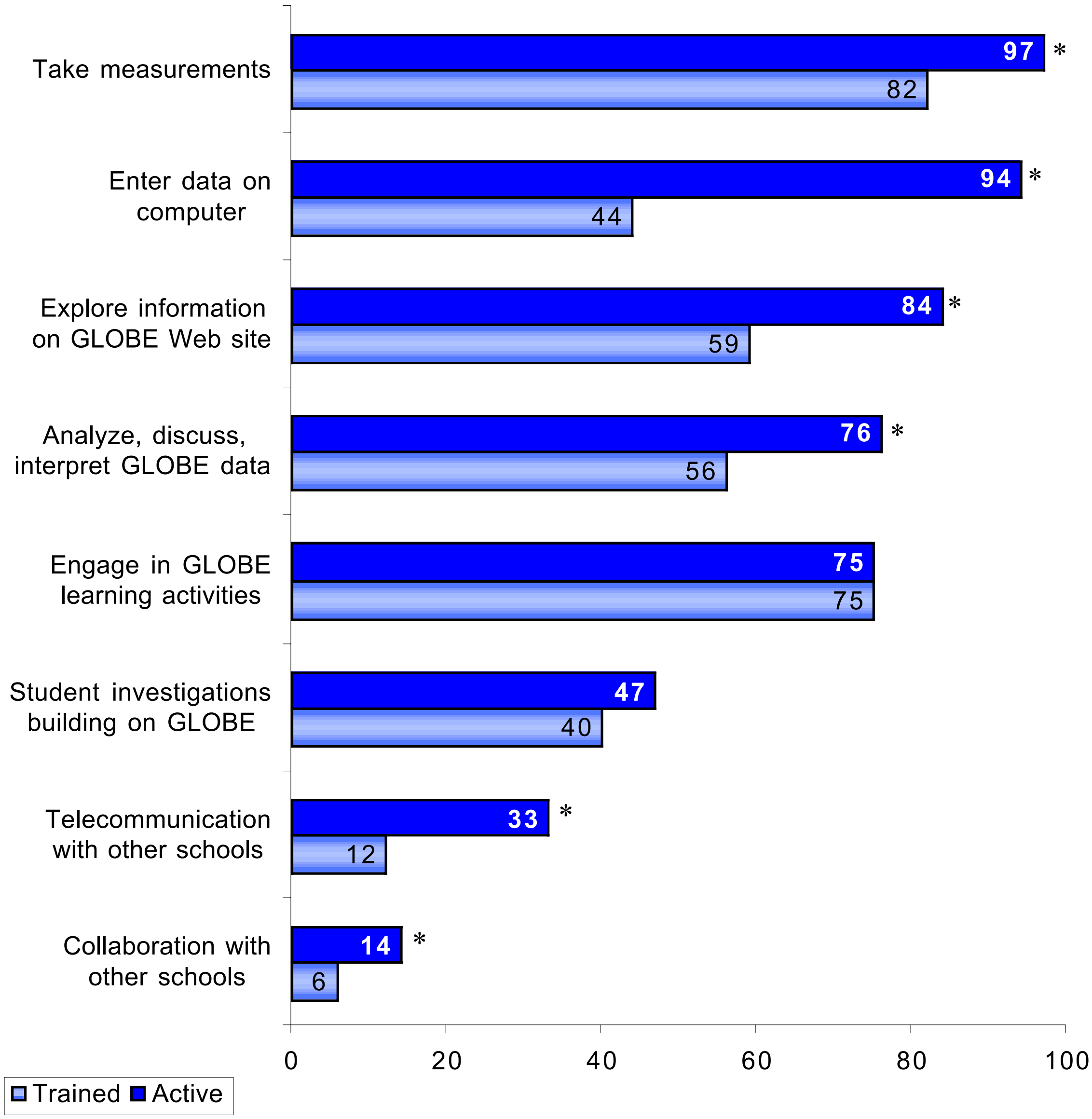
The decrease in time spent preparing for GLOBE activities is consistent with the hypothesis that the workload for GLOBE implementation is more often being shared among teachers because there has been an increase in the proportion of schools with multiple GLOBE teachers. It is also possible that the decrease in time spent preparing for GLOBE activities can be attributed in part to teacher learning and an improvement in the usability of GLOBE materials (e.g., revised reporting forms, availability of Teacher's Guide materials on the Web site). While trained teachers in Year 5 spent less time preparing each week for GLOBE (1.7 hours) than did trained teachers in Year 3 (2.2 hours), active teachers in Year 5 spent less time preparing (1.2 hours) than teachers in either of these other two groups, even though they spent more time on GLOBE activities with students.

Implementation of Specific Components of GLOBE

Current Practices

In 1999-2000, GLOBE teachers continued to involve their students in a wide range of the program components. Figure 4.4 shows that students were especially involved in five core GLOBE components—taking measurements, entering data on the computer, exploring information on the GLOBE Web site, analyzing GLOBE data, and engaging in GLOBE learning activities.

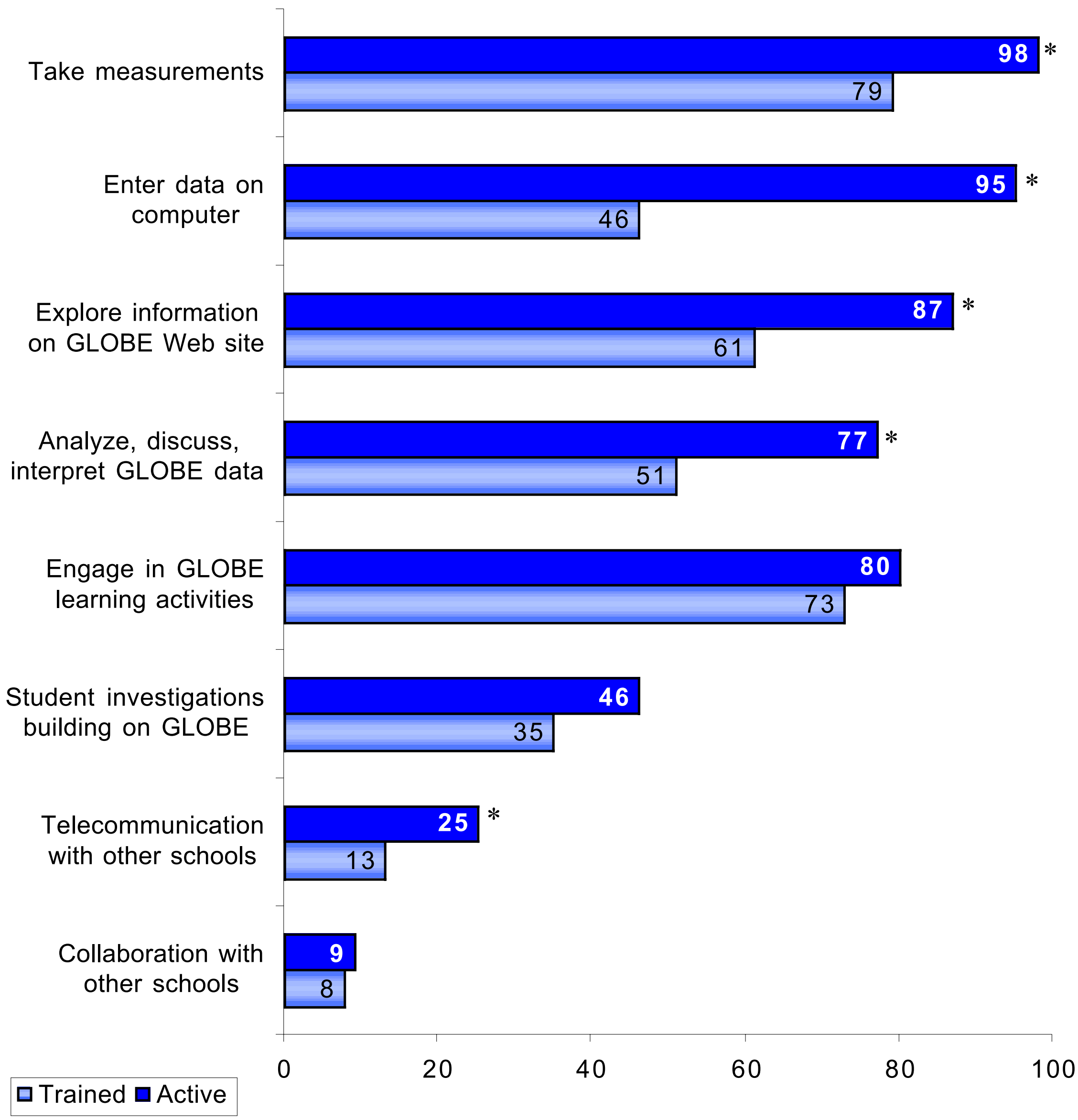
Figure 4.4
Percentage of Y5 Trained and Active Teachers Implementing GLOBE Components with Students



Sample sizes: Trained n = 253, Active n = 468

*Difference between trained and active respondents significant at $p < .05$

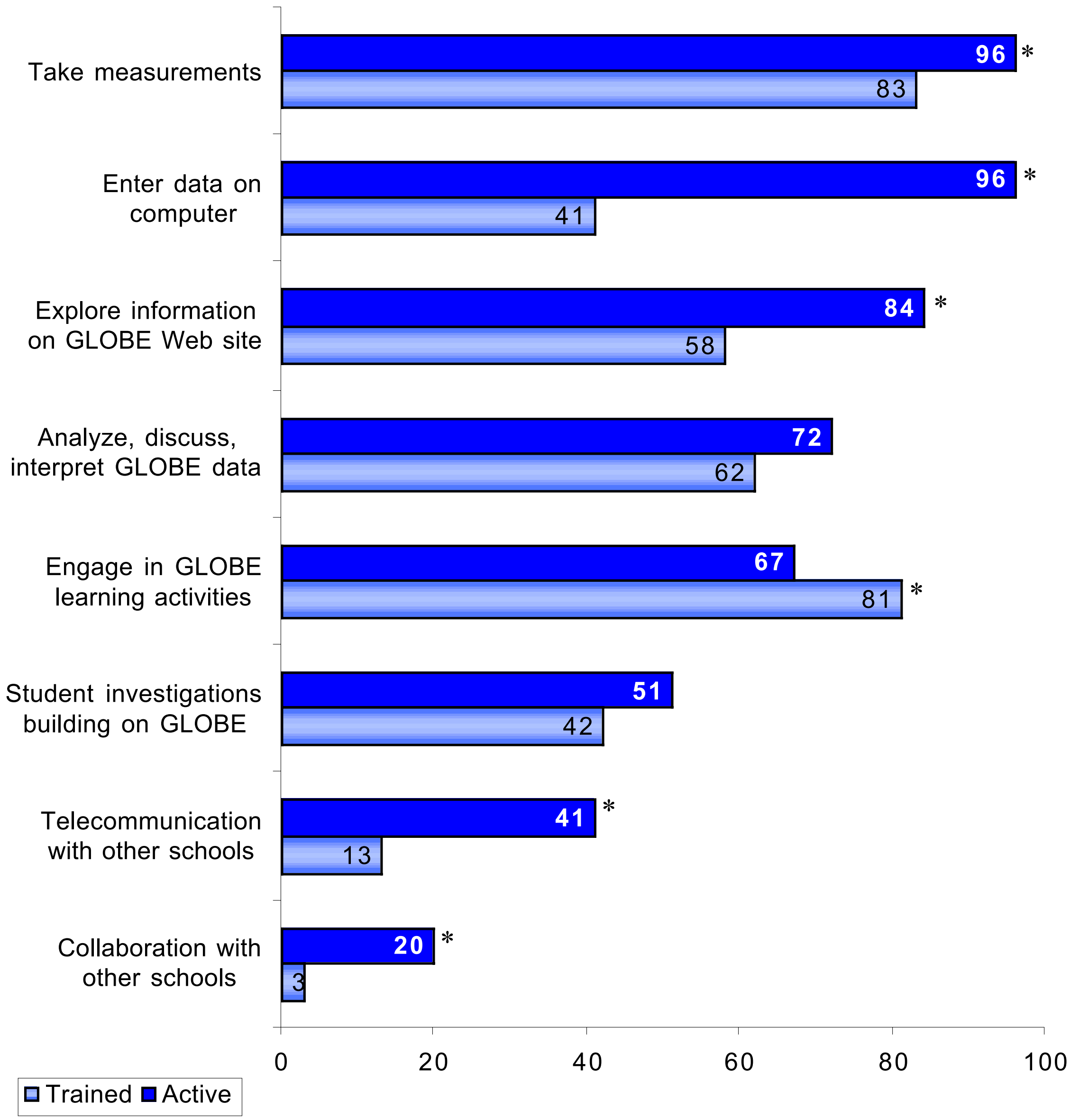
Figure 4.4a
Percentage of Y5 Trained and Active Elementary School Teachers Implementing GLOBE Components with Students



Sample sizes: Trained n = 106, Active n = 171

*Difference between trained and active respondents significant at p < .05

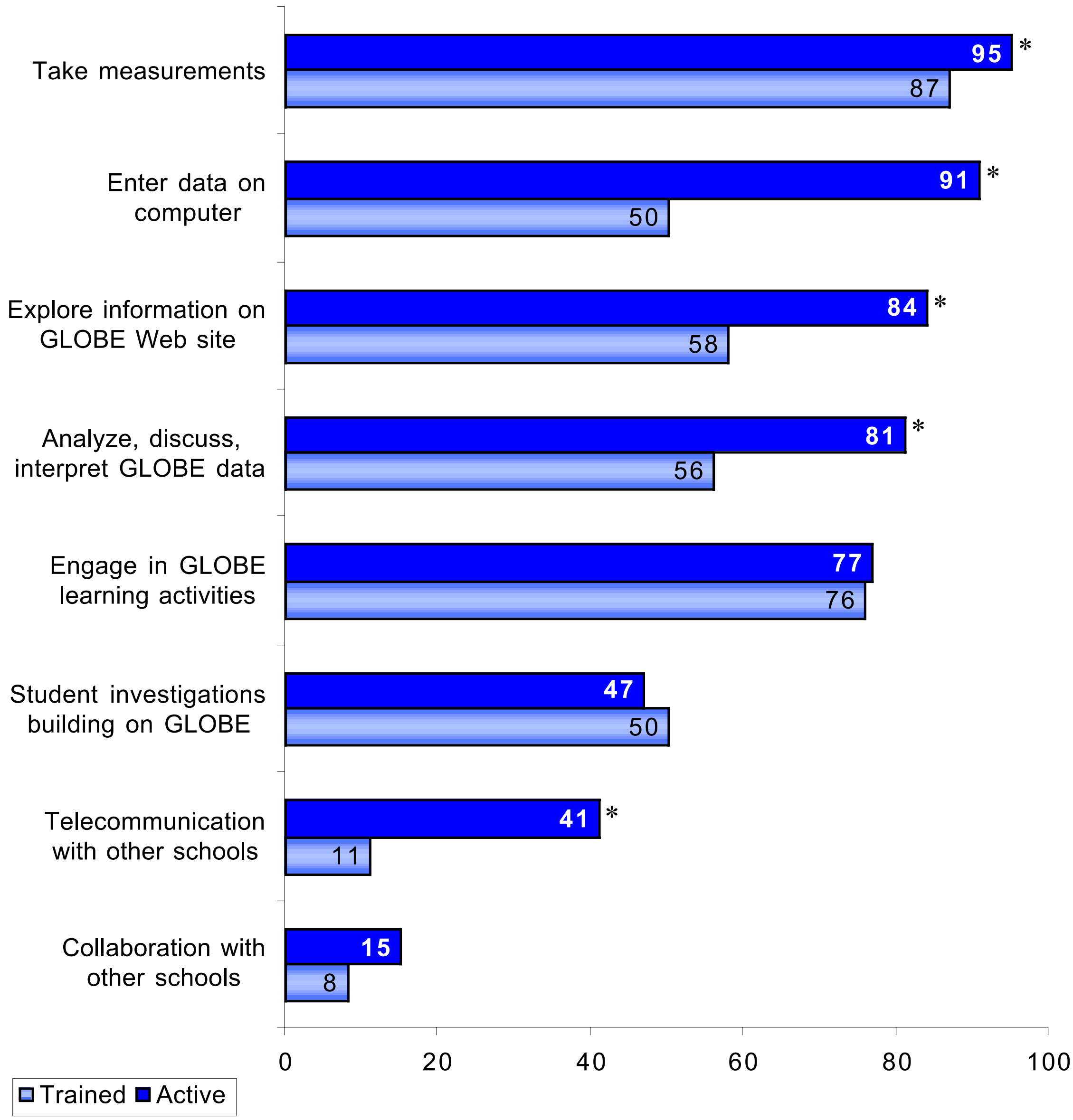
Figure 4.4b
Percentage of Y5 Trained and Active Middle School Teachers Implementing GLOBE Components with Students



Sample sizes: Trained n = 69, Active n = 135

*Difference between trained and active respondents significant at p < .05

Figure 4.4c
Percentage of Y5 Trained and Active High School Teachers Implementing GLOBE Components with Students



Sample sizes: Trained n = 62, Active n = 129

*Difference between trained and active respondents significant at p < .05

Given the way the active sample was chosen, it is no surprise that active teachers are more likely than recently trained teachers implementing GLOBE to have their students collect data and enter it on the computer. More interesting is the fact that active teachers are more likely also to have students exploring GLOBE web resources, analyzing and discussing GLOBE data, and telecommunicating with other schools. Based on our survey data, we can not say whether more extensive involvement in data collection leads to these other activities or vice versa. We do know, however, that they tend to occur together. Active GLOBE teachers and recently trained teachers did not differ significantly in the likelihood of engaging students in GLOBE learning activities (75% of samples) or initiating student investigations building on GLOBE (47% and 40% of the active and trained samples, respectively). Both active and trained teachers do relatively little in the way of collaborating with other schools, as Figure 4.4 also shows.

Virtually all of the active teachers who reported that they had implemented GLOBE with students also reported having their students take measurements (97%) and almost as many active teachers reported involving their students in submitting data (94%). These figures are not unexpected, given the way the active sample was drawn, but do suggest that teachers at active GLOBE schools view both data collection and data reporting as central to GLOBE implementation. Among recently trained teachers, the picture is somewhat different. Recently trained teachers who are implementing GLOBE with students are highly likely to have their students collect data (82%) but much less likely to involve students in submitting data to the Student Data Archive (44%).

The GLOBE Program has been trying to understand the reasons why so many teachers have their students collect data but do not report the measurements to the data archive. One possible reason for the difference in data reporting rates for the two survey samples is that, relative to their more experienced counterparts in the active teacher sample, teachers trained in 1999-2000 favor using elements of the GLOBE Program more for the purposes of teaching and learning than for the purpose of contributing to the GLOBE database. This interpretation is strengthened by the findings showing that recently trained teachers engage in GLOBE learning activities at as high a rate as active teachers (both at 75%, as shown above).

Teachers were asked to respond to a survey item listing possible reasons that their school did not report data that their students had collected. Table 4.7 shows the reasons that student-collected data were not reported by recently trained and active U.S. teachers.

Although the responses of trained and active teachers who cited a lack of confidence in the quality of the measurements their students have taken are quite similar (63% v. 60%, respectively), these results suggest that recently trained teachers are more likely than active teachers to have doubts concerning the measurement quality. Active teachers, on the other hand, are more likely to have had data sets they intended to report that did not get entered (46% v. 25%). The other two top reasons for not sending data are decidedly practical in nature: difficulties finding time or using technology. Finally, some

25% of trained teachers and 12% of active teachers responded that they did not submit data because they believed "that the value lies more in taking the data than in reporting it." Many of the open-ended responses to this survey item seemed to indicate that some teachers value data reporting less than data collection and may choose to dispense with the former in the face of perceived time pressures. One teacher wrote, for example, "No time [for data reporting], I just want [students] to understand the concepts."

Table 4.7
Reasons for Not Submitting Data
(Percent Reporting)

Reason Cited as Minor or Major	*U.S. Trained*	*U.S. Active*
Difficulty finding time to submit the data to the archive	65	63
Lack of confidence that the measurements were taken correctly	63	60
Internet connection not working or unavailable	57	59
Delegated reporting to others who did not get it done	25	46*
Belief that value lies more in taking the data than in reporting it	25*	12
Sample sizes:	$155 \le n \le 166$	$173 \le n \le 187$

*Difference between trained and active respondents significant at $p < .05$

For those aspects of GLOBE that teachers implement with students, we wanted to ascertain the way in which the classes were organized for these activities. Table 4.8a shows the teacher responses. The teachers in our survey sample reported organizing their students for GLOBE work in different types of groupings, depending on the GLOBE component with which they were engaged. Teachers typically had a single small group of students or multiple small groups take GLOBE measurements. Single small groups also entered GLOBE data into the computer and explored information on the GLOBE Web site. Teachers typically involved the whole class for discussions of GLOBE data and for GLOBE learning activities. In sum, hands-on data collection and activities involving computer use were undertaken in small groups, while discussion and learning activities involved the whole class.

Tables 4.8b-d show how teachers at different grade levels organized their students for GLOBE activities. Classroom management patterns are quite consistent across grade levels. At all grades, use of small groups for data collection and reporting and whole-class participation in learning activities predominate. Having a single student enter GLOBE data and having multiple small groups analyze and discuss data are two practices that are more common at the high school level than in earlier grades.

Table 4.8a
Trained and Active 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		Adult		No One	
Sample	Trained	Active	Trained	Active	Trained	Active	Trained	Active	Trained	Active	Trained	Active
Take GLOBE measurements	3	5	54	69	22	21	8	4	<1	<1	13	<1
Enter GLOBE data on computer	9	16*	28	58*	5	12*	3	3	13*	10	42*	1
Explore information on GLOBE Web site	4	8*	10	24*	7	7	7	11*	11	18	61*	32
Analyze, discuss, interpret GLOBE data	<1	<1	11	20	13	11	46	50	3	2	27	17
Engage in GLOBE learning activities	1	1	10	13	20	11	56	59	0	1	13	15

Sample sizes: Trained = 243 ≤ n ≤ 260, Active = 445 ≤ n ≤ 470
* Difference between Trained and Active respondents significant at p < .05

Table 4.8b
Trained and Active Elementary 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		Adult		No One	
Sample	Trained	Active	Trained	Active	Trained	Active	Trained	Active	Trained	Active	Trained	Active
Take GLOBE measurements	2	2	58	71	18	21	8	4	1	1	13	1
Enter GLOBE data on computer	4	9	33	65	7	14	3	1	12	9	41	2
Explore information on GLOBE Web site	3	7	14	23	9	8	4	8	9	19	61	35
Analyze, discuss, interpret GLOBE data	0	1	14	20	12	7	44	54	3	1	27	17
Engage in GLOBE learning activities	1	0	9	12	20	10	61	66	0	0	9	12

Sample sizes: Trained = 105 ≤ n ≤ 108, Active = 165 ≤ n ≤ 173

Table 4.8c
Trained and Active Middle School 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		Adult		No One	
Sample	Trained	Active	Trained	Active	Trained	Active	Trained	Active	Trained	Active	Trained	Active
Take GLOBE measurements	2	7	58	64	18	24	8	4	1	1	13	0
Enter GLOBE data on computer	4	19	33	56	7	10	3	4	12	11	41	0
Explore information on GLOBE Web site	3	7	7	24	3	7	11	16	13	17	63	29
Analyze, discuss, interpret GLOBE data	0	0	5	16	3	11	55	54	5	2	31	16
Engage in GLOBE learning activities	1	2	5	9	21	9	57	64	0	2	16	14

Sample sizes: Trained = 62 ≤ n ≤ 68, Active = 125 ≤ n ≤ 133

Table 4.8d
Trained and Active High School Teacher Reports of Student Participation in GLOBE Activities in a Typical Week
(Percent Reporting)

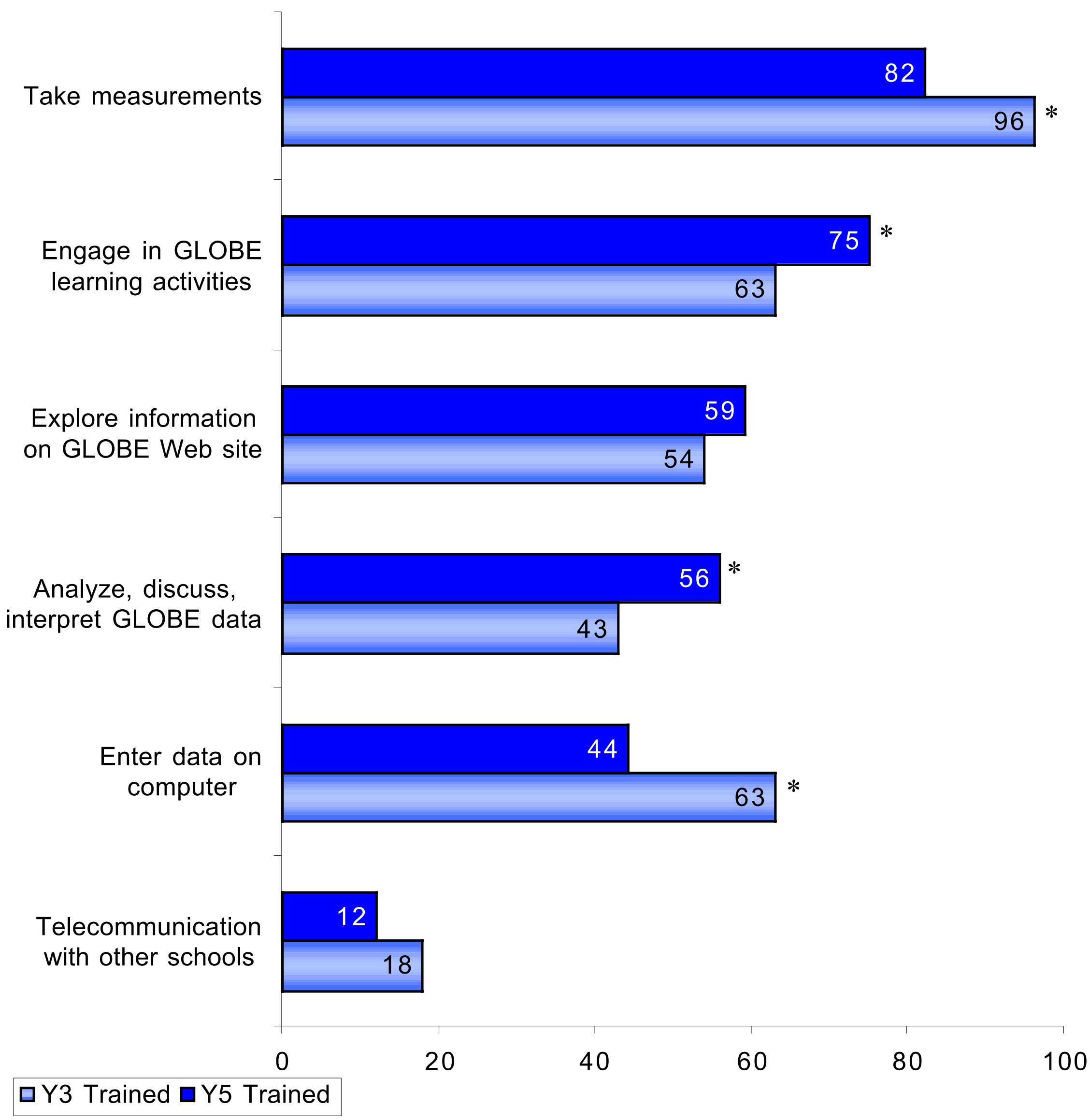
GLOBE Activity	Single Student		Small Group		Multiple Small Groups		Whole Class		Adult		No One	
Sample	Trained	Active	Trained	Active	Trained	Active	Trained	Active	Trained	Active	Trained	Active
Take GLOBE measurements	7	7	49	67	27	21	7	4	0	1	10	0
Enter GLOBE data on computer	17	26	24	49	8	11	0	2	14	10	37	2
Explore information on GLOBE Web site	6	11	6	22	8	6	8	11	13	16	59	34
Analyze, discuss, interpret GLOBE data	2	1	15	24	21	18	33	39	3	2	26	16
Engage in GLOBE learning activities	1	2	17	18	20	16	47	45	0	1	15	18

Sample sizes: Trained = 63 ≤ n ≤ 71, Active = 123 ≤ n ≤ 131

Trends

Trained teachers in Year 5 involved students in the major components of the GLOBE Program at levels that differed somewhat from the trained teachers sampled in Year 3, as shown in Figure 4.5. Recently trained teachers in Year 5 were more likely than those in Year 3 to involve students in learning activities (75% for Year 5 compared with 63% for

Figure 4.5
Percentage of Trained Teachers Implementing GLOBE Components with Students, Y3 and Y5



Sample sizes: Y3 = 192, Y5 = 253

* Difference between Y3 and Y5 respondents significant at $p < .05$
Note: The Year 3 survey did not ask about student investigations or collaborations with other schools.

Year 3) and in analysis, discussion, and interpretation of GLOBE data (56% for Year 5 compared with 43% in Year 3). Two of the other components of the GLOBE Program for which there are comparable data for both Years 3 and 5 show a decrease in teacher implementation with students. Trained teachers implementing GLOBE were less likely to report involving students in taking measurements in Year 5 (82% versus 96% for Year 3) and much less likely to involve students in entering GLOBE data on the computer (44% compared to 63% in Year 3). Although this latter finding could be interpreted as reflecting a decrease in teachers' emphasis on participating in the wider GLOBE Program, the Year 5 survey data do not fully bear this out. Instead, as suggested above, data reporting seems to get left undone for the same types of pragmatic reasons that influence other GLOBE implementation practices: time, technology, and skills.

Patterns of organizing students into different groupings (e.g., small group, whole class, etc.) for GLOBE activities are similar in Years 3 and 5, with trained teachers in both years predominantly using a whole-class grouping for data analysis and engaging in GLOBE learning activities. Our survey data indicate, however, that trained teachers in Year 5 shifted somewhat toward more use of multiple small groups rather than either single groups or whole class groupings for data analysis, data collection, and learning activities. For example, Year 5 survey answers from trained teachers indicated modest increases over Year 3 in use of multiple small groups for data collection. In general, these types of changes may signal the beginning of a trend toward organizing students into small groups to work on GLOBE activities in parallel more often. This preliminary finding might reflect efforts by the GLOBE organization to encourage more use of multiple small groups in implementing GLOBE activities with students.

Implementation of GLOBE Data Collection Protocols

Current Practices

Tables 4.9 through 4.12 show the details of implementation rates for individual GLOBE protocols within the four main areas of investigation. Teachers implementing GLOBE with students were asked to indicate which specific protocols they had implemented, either by themselves or in conjunction with another teacher, and which protocols had been implemented by others at their school. For each protocol, data regarding implementation are broken into categories reflecting the responding teacher's own efforts at implementation ("Self") and efforts by anyone at the teacher's school, including the individual teacher reporting ("School"). Since implementation rates for some protocols and activities vary considerably by school level, elementary school implementation rates are shown separately from those of middle and secondary schools.

Atmosphere. As presented in Table 4.9, most of the Atmosphere protocols were implemented by the overwhelming majority of active GLOBE teachers and by half or more of the recently trained teachers as well. These protocols include Cloud Type, Cloud Cover, Rainfall, and Min/Max/Current Temperatures. We can see from the data that for all Atmosphere protocols, recently trained teachers implemented protocols at a lower rate than active teachers at the same grade level ("Self" category). This difference in some instances is quite dramatic—e.g., at the elementary level, 94% of active teachers implemented the Rainfall protocol in comparison to 74% of recently trained teachers. When we examine implementation rates at the school rather than the individual level, we find that among elementary GLOBE programs the gap between active and trained teacher samples is reduced. The active sample still has higher rates of implementation, but the differences are less dramatic (e.g., 97% versus 85% for Rainfall at the elementary level).

This suggests a level of specialization among recently trained teachers, since their schools are implementing protocols at higher rates than the individual teachers do. Within the active sample, the differences between "Self" and "School" rates are quite small, suggesting that there is relatively little supplementation of the data collections led by the single most active teacher within the Atmosphere investigation.

Table 4.9
Atmosphere Protocol Implementation, by Trained and Active Teachers
(Percent Reporting)

Protocol	*Elementary*				*Middle/Secondary*			
	Trained Teachers		*Active Teachers*		*Trained Teachers*		*Active Teachers*	
	Self	*School†*	*Self*	*School†*	*Self*	*School†*	*Self*	*School†*
Cloud Type	88	94	97*	99	81	86	95	100*
Cloud Cover	86	95	97*	99	81	85	95	100*
Rainfall	74	85	94*	97*	71	79	94*	99*
Precipitation pH	43	57	73*	75*	57	66	79*	82*
Solid Precipitation	43	55	75*	77*	50	55	76*	80*
Max/Min and Current Temperatures	76	86	96*	98*	73	81	95*	100*
Sample sizes:	86 ≤ n ≤ 105		159 ≤ n ≤ 175		120 ≤ n ≤ 135		238 ≤ n ≤ 264	

†In the Year 5 survey, teachers were asked if the protocol was implemented by: the teacher, the teacher and another teacher, or solely by another teacher or teachers in the school. The "School" response column counts a response to any of these categories as being implemented in the school.

* Within each grade level and report type (self or school) trained and active teacher responses were compared. Differences are significant at p < .05

Teacher-reported rates of implementation were roughly comparable for teachers at the elementary and the middle/secondary school levels. However, for Cloud Cover, Cloud Type, and Precipitation pH, recently trained teachers at the middle/secondary level implemented these protocols at significantly higher rates than at the elementary level. Recently trained teachers at the middle/high school level were also somewhat more likely than their elementary counterparts to be implementing the less common Atmosphere protocols (i.e., Precipitation pH and Solid Precipitation) themselves (“Self” category).

Hydrology. The most commonly implemented Hydrology protocols at both the elementary and secondary levels were Water Temperature and Water pH, used in close to 40% of elementary GLOBE schools and approximately 60% of the middle and secondary schools (Table 4.10). Although some of the protocols (Dissolved Oxygen, Alkalinity, Salinity Titration, and Nitrate) are not expected to be performed at the elementary level, a notable number of elementary teachers, especially recently trained teachers, reported implementing these protocols at the elementary level.

It is interesting to note that at the secondary level Hydrology protocols are implemented at approximately equal rates by trained and active teachers. Roughly speaking, the less commonly implemented the protocol, the more likely the rates of implementation by recently trained teachers will match or exceed the rates of active teachers. Compare, for example, the rates of implementation for Water Temperature, one of the more commonly implemented protocols, and the rates for Salinity, a less frequently implemented protocol. Trained middle and secondary teachers implemented Water Temperature at a somewhat lower rate than their active teacher counterparts (but not significantly so), but they implemented Salinity at a higher rate than their active teacher counterparts. This finding supports the idea that recently trained teachers are “filling in” gaps in protocol implementation, an idea supported by other findings reported in this chapter.

Rates of implementation in the Hydrology investigation area reported by the recently trained teachers are generally as high or higher than those reported by active samples for both individual teachers (“Self” category) and collectives of teachers at a given school (“School” category). This finding contrasts with the findings for those Atmosphere protocols which trained teachers are less likely to implement than active teachers at both the high school and elementary levels. Taken together, these two findings suggest that recently trained teachers are moving more towards implementing non-Atmosphere protocols, perhaps leaving the Atmosphere protocols to other GLOBE teachers at their schools. All protocols except Salinity Titration (“Self” category) are implemented at a significantly higher rate at the middle/secondary level than at the elementary level.

Table 4.10
Hydrology Protocol Implementation, by Y5 Trained and Active Teachers
(Percent Reporting)

Protocol	Elementary				Middle/Secondary			
	Trained Teachers		Active Teachers		Trained Teachers		Active Teachers	
	Self	School†	Self	School†	Self	School†	Self	School†
Water Temperature	26	40	33	38	48	57	58	64
Dissolved Oxygen	18	29*	16	19	47	56	45	50
pH	28	40	33	37	50	58	59	65
Alkalinity	16	27*	11	14	39	47	39	43
Water Transparency	21	30	19	22	46	53	41	44
Nitrate	11	17	7	9	38	46	33	38
Electrical Conductivity	11	18	11	13	37	42	40	45
Salinity	9	15*	4	5	23*	29*	14	16
Salinity Titration	4	11*	3	4	14	20*	8	10
Implemented any of: Electrical Conductivity, Salinity, or Salinity Titration	13	20	12	14	41	47	43	48
Sample sizes:	90 ≤ n ≤ 96		143 ≤ n ≤ 163		116 ≤ n ≤ 131		194 ≤ n ≤ 240	

†In the Year 5 survey, teachers were asked if the protocol was implemented by: the teacher, the teacher and another teacher, or solely by another teacher or teachers in the school. The "School" response column counts a response to any of these categories as being implemented in the school.

* Within each grade level and report type (self or school) trained and active teacher responses were compared. Differences are significant at $p < .05$

Land Cover/Biology. Table 4.11 shows that the most commonly implemented protocols in the Land Cover/Biology investigation area were Qualitative Land Cover, Quantitative Land Cover, and Biometry. Since Qualitative Land Cover, Quantitative Land Cover, and Biometry all require completion of the site's MUC System Classification, we would expect to find the highest implementation rates for MUC, but that was not the case. Few teachers at the elementary level implemented MUC System or Land Cover Mapping, and even fewer implemented Accuracy Assessment. Elementary teachers generally implemented individual protocols at less than half the rate of their secondary counterparts.

Individual trained teachers implemented Land Cover/Biology protocols at rates similar to those of active teachers (the "Self" category). Biometry is the only protocol implemented more frequently by active than by recently trained teachers at the elementary level. At the middle/secondary level, Biometry and MUC System were implemented more commonly by active teachers. None of the differences between school-level implementation rates reported by the trained and active teacher samples at the elementary level were significant.

Active middle/secondary respondents at both "Self" and "School" categories implemented all Land Cover/Biology protocols at significantly higher rates than those at elementary level except for the Accuracy Assessment protocol. Recently trained middle/secondary school teachers ("Self" category), implemented all Land Cover/Biology protocols except for MUC System and Land Cover Mapping at a significantly higher rate than recently trained elementary teachers. However, these differences were not significant for trained teachers in the "School" respondent category.

Table 4.11
Land Cover/Biology Protocol Implementation, by Year 5 Trained and Active Teachers (Percent Reporting)

Protocol	*Elementary*				*Middle/Secondary*			
	Trained Teachers		*Active Teachers*		*Trained Teachers*		*Active Teachers*	
	Self	*School†*	*Self*	*School†*	*Self*	*School†*	*Self*	*School†*
Qualitative Land Cover	15	24	19	23	28	31	37	41
Quantitative Land Cover	15	25	19	21	30	33	32	36
Biometry	5	12	14*	17	17	20	31*	36*
MUC System	8	13	10	13	15	18	29*	32*
Land Cover Mapping	9	16	10	11	16	18	19	21
Accuracy Assessment	4	10	6	7	12	14	11	13
Sample sizes:	91 ≤ n ≤ 93		154 ≤ n ≤ 160		120 ≤ n ≤ 128		207 ≤ n ≤ 227	

†In the Year 5 survey, teachers were asked if the protocol was implemented by: the teacher, the teacher and another teacher, or solely by another teacher or teachers in the school. The "School" response column counts a response to any of these categories as being implemented in the school.

* Within each grade level and report type (self or school) trained and active teacher responses were compared. Differences are significant at $p < .05$

Soil. The most commonly implemented Soil protocols were Soil Field Measurements, Soil Lab Analysis, and Soil Temperature. About 30% of recently trained middle and secondary teachers implemented these protocols, and 13-18% of recently trained elementary teachers did so. Few teachers, especially at the elementary level, implemented Gravimetric or Gypsum Block Soil Moisture protocols.

Table 4.12 shows that recently trained teachers ("Self") and GLOBE teams at their schools ("School") implemented Soil protocols at rates typically equal to or higher than rates reported by teachers in the active-school sample. This finding is strongest at the elementary school-wide level, where we see, for example, that Soil Field Measurements and Soil Lab Analysis protocols are almost twice as likely to be implemented at schools of recently trained teachers as among teachers in the active-school sample. These data suggest that Soil protocols received greater emphasis in GLOBE training programs in 1998-1999 than in previous years, and that, again, teaching teams at GLOBE schools are putting more effort into balancing implementation across investigation areas. These trends will be discussed further below.

Table 4.12
Soil Protocol Implementation, by Trained and Active Teachers
(Percent Reporting)

Protocol	Elementary				Middle/Secondary			
	Trained Teachers		Active Teachers		Trained Teachers		Active Teachers	
	Self	School†	Self	School†	Self	School†	Self	School†
Soil Characterization Field Measurements	18	26*	11	14	30	40	29	32
Soil Characterization Lab Analysis	15	22*	9	12	28	36	23	27
Soil Temperature	13	22*	8	10	32	39	28	31
Infiltration	9	16*	5	6	25*	31*	16	18
Gravimetric Soil Moisture	4	12	4	5	14	18	13	16
Gypsum Block Soil Moisture	2	9	3	4	7	10	10	11
Implemented any Soil Moisture protocol	4	12	4	6	16	19	16	19
Sample sizes:	91 ≤ n ≤ 94		153 ≤ n ≤ 158		117 ≤ n ≤ 129		204 ≤ n ≤ 223	

†In the Year 5 survey, teachers were asked if the protocol was implemented by: the teacher, the teacher and another teacher, or solely by another teacher or teachers in the school. The "School" response column counts a response to any of these categories as being implemented in the school.

* Within each grade level and report type (self or school) trained and active teacher responses were compared. Differences are significant at $p < .05$

Since multiple soil moisture protocols are offered as options, we ran additional analyses examining the proportion of teachers implementing either or both protocols. At the elementary level, 4% of recently trained teachers and active teachers implement a soil moisture protocol of some kind. The comparable figure for both recently trained and active middle/secondary teachers is 16%.

When comparing the implementation rates across school levels, almost all Soil protocols were implemented at a significantly higher rate at the middle/secondary level than at the elementary level.

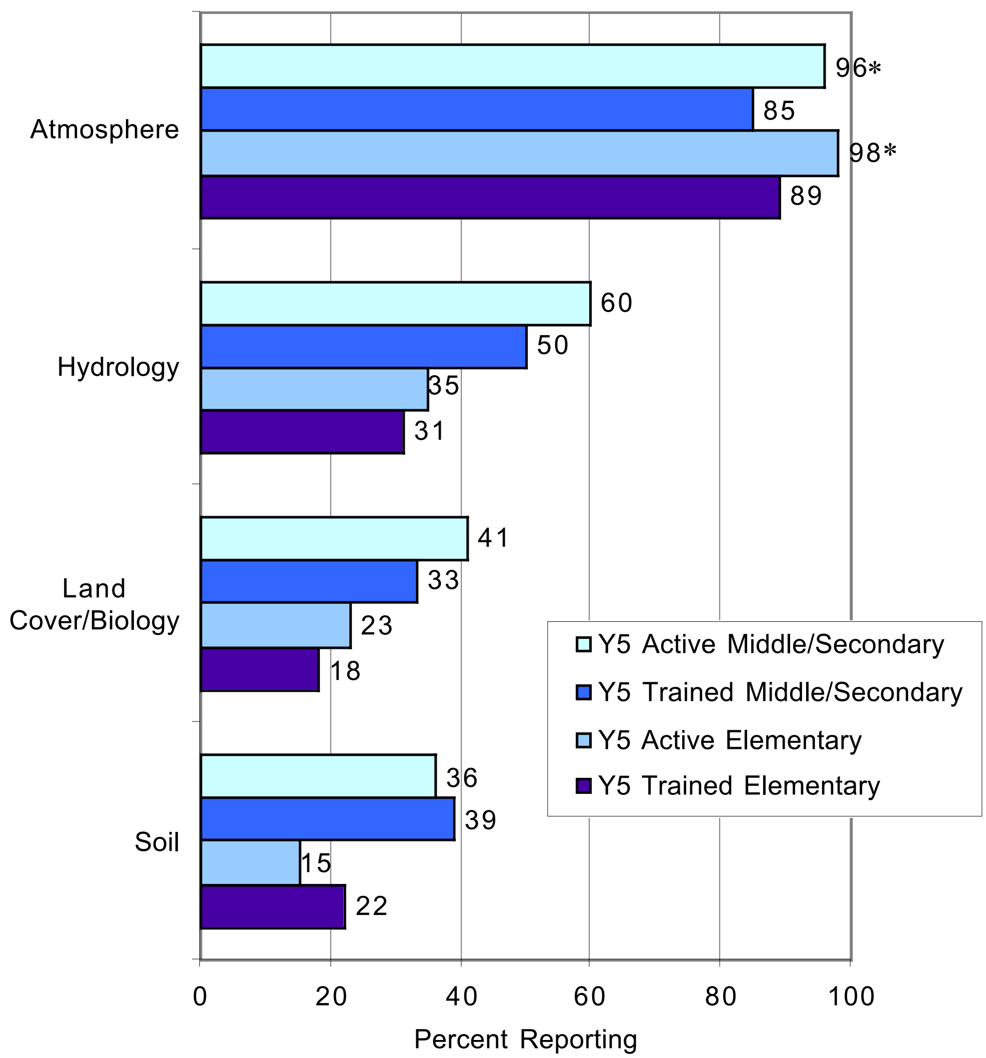
Summary of Current Practices for Protocol Implementation. To provide a broader picture of the implementation of GLOBE investigations across schools, we determined for each survey respondent whether at least one protocol in an investigation area was implemented at the teacher's school. Figure 4.6 presents data for both trained and active teachers who reported that their schools implemented one or more protocols within an investigation area. The Atmosphere investigation remains the most commonly implemented, followed (in order) by Hydrology, and then Land Cover/Biology and Soil (which have similar implementation rates). With the exception of Atmosphere, middle/secondary schools have higher implementation rates than elementary schools. Teachers in the active sample report significantly higher implementation rates than do those in the recently trained sample only in the case of the Atmosphere investigation area.

Trends

Tables 4.13 through 4.16 compare the implementation rates for individual GLOBE protocols between Years 3 and 5. Elementary school implementation rates are shown separately from those of middle and secondary schools because of the substantial differences in these rates between the two school levels. Interpretation of the survey responses across years is complicated somewhat by a change in the survey items. The Year 5 survey asked teachers to report both on protocols they implemented individually and on those implemented within their school by any teacher, including themselves.[6] In contrast, the Year 3 survey asked teachers only about protocols they themselves implemented with their most active GLOBE class. It is possible that in some cases, Year 3 teachers "counted" protocols implemented by colleagues in their responses. Nevertheless, the Year 3 reports and the "Self" reports for Year 5 are roughly comparable.

[6] The actual survey item asked teachers to indicate for each protocol whether it was implemented by them alone, by them along with one or more other teachers at their school, or by one or more other teachers but not them. For data reporting purposes, individual and school implementation rates were imputed from these responses.

Figure 4.6
Protocol Implementation, by Y5 Trained and Active Teachers



Sample sizes: Y5 Active Middle/Secondary 229 ≤ n ≤ 264, Y5 Trained Middle/Secondary 107 ≤ n ≤ 130, Y5 Active Elementary 160 ≤ n ≤ 175, Y5 Trained Elementary 94 ≤ n ≤ 107

* Difference between trained and active respondents significant at $p < .05$

While the Atmosphere protocols remain the most widely implemented protocols in GLOBE overall, there have been notable increases at all school levels in the implementation of the Hydrology, Land Cover/Biology, and Soil protocols between Years 3 and 5. These data suggest a significant broadening of the GLOBE experience for GLOBE students. These data also suggest that despite the amount and complexity of material in GLOBE, teachers can nonetheless successfully implement an extended range of protocols, given adequate time and training.

Although the largest increases occurred for non-Atmosphere protocols at the middle- and high-school level, Hydrology and Soil showed significant increases in rates of implementation at the elementary level as well. This is particularly interesting given that some of the protocols in these non-Atmosphere categories are not intended for elementary implementation.

Atmosphere. Recently trained teachers completing the Year 5 survey were overall slightly less likely to be implementing many of the Atmosphere protocols themselves than were their counterparts from the Year 3 survey, but none of these declines was significant, as shown in Table 4.13. Moreover, the Year 5 reported implementation rates at the school level are higher than the Year 3 reported rates. These data are consistent with the view that recently trained teachers are specializing more than such teachers trained in earlier cohorts did, balancing out implementation of protocols across investigation areas at the school-wide level while maintaining high implementation rates for the most commonly implemented protocols. For less commonly implemented Atmosphere protocols (Precipitation pH and Solid Precipitation) we found increases in implementation among recently trained middle and secondary teachers.

Table 4.13
Atmosphere Protocol Implementation, by Year 3 and Year 5 Trained Teachers (Percent Reporting)

Protocol	*Elementary*			*Middle/Secondary*		
	Y3 Trained Teachers	*Y5 Trained Teachers*		*Y3 Trained Teachers*	*Y5 Trained Teachers*	
	Self	*Self*	*School†*	*Self*	*Self*	*School†*
Cloud Type	92	88	94	86	81	86
Cloud Cover	91	86	95	83	81	85
Rainfall	78	74	85	68	71	79
Precipitation pH	39	43	57	37	57*	66
Solid Precipitation	50	43	55	36	50*	55
Max/Min and Current Temperatures	77	76	77	71	73	81
Sample sizes:	68 ≤ n ≤ 74	86 ≤ n ≤ 105		101 ≤ n ≤ 116	120 ≤ n ≤ 135	

†In the Year 5 survey, teachers were asked if the protocol was implemented by: the teacher, the teacher and another teacher, or solely by another teacher or teachers in the school. The "School" response column counts a response to any of these categories as being implemented in the school

* Difference between Y3 and Y5 respondents significant at $p < .05$

Hydrology. Implementation rates for Hydrology protocols increased sizably between Years 3 and 5, as shown in Table 4.14. Water Temperature, pH, and Dissolved Oxygen continued to be the most widely implemented Hydrology protocols. Electrical Conductivity, Dissolved Oxygen, Water Transparency and Nitrate all showed a significant increase from Year 3 to Year 5 at both grade levels. Among recently trained teachers at the elementary level in Year 5, 11% reported that they implemented Nitrate, whereas none of the elementary teachers in the Year 3 sample reported implementing this protocol. (It should be noted that Nitrate is not recommended by the GLOBE Program for implementation at the elementary level.)

Table 4.14
Hydrology Protocol Implementation, by Year 3 and Year 5 Trained Teachers (Percent Reporting)

Protocol	Elementary			Middle/Secondary		
	Y3 Trained Teachers	Y5 Trained Teachers		Y3 Trained Teachers	Y5 Trained Teachers	
	Self	Self	School†	Self	Self	School†
Water Temperature	25	27	40	33	48*	57
Dissolved Oxygen	6	18*	29	26	47*	56
pH	20	28	40	35	50*	58
Alkalinity	8	16	27	25	39*	47
Electrical Conductivity	2	11*	18	18	37*	42
Water Transparency	5	21*	30	19	46*	53
Salinity	3	9	15	8	23*	29
Salinity Titration	2	4	11	6	14	20
Nitrate	0	11*	17	15	38*	46
Sample sizes:	62 ≤ n ≤ 66	90 ≤ n ≤ 96		105 ≤ n ≤ 113	116 ≤ n ≤ 131	

†In the Year 5 survey, teachers were asked if the protocol was implemented by: the teacher, the teacher and another teacher, or solely by another teacher or teachers in the school. The “School” response column counts a response to any of these categories as being implemented in the school.

* Difference between Y3 and Y5 respondents significant at $p < .05$

Land Cover/Biology. Implementation rates for individual Land Cover/Biology protocols increased at the middle/secondary level between Year 3 and Year 5. At the elementary level, individual teachers implemented protocols in this investigation area at comparable rates in Years 3 and 5. Reported implementation rates in the “school” category are considerably higher than the rates of individual implementation, however.

At the secondary level, individual trained teachers in Year 5 implemented Land Cover/Biology protocols at rates greater than their Year 3 counterparts, but also reported school-wide implementation rates greater than their own. For example, Table 4.15 shows that 12% of trained teachers at the secondary level in Year 3 implemented the Quantitative Land Cover protocol, 30% of comparable teachers implemented this protocol in Year 5, and 33% of the Year 5 teachers reported that this protocol was implemented at their school.

Table 4.15
Land Cover/Biology Protocol Implementation, by Year 3 and Year 5 Trained Teachers (Percent Reporting)

Protocol	Elementary			Middle/Secondary		
	Y3 Trained Teachers	Y5 Trained Teachers		Y3 Trained Teachers	Y5 Trained Teachers	
	Self	Self	School†	Self	Self	School†
Qualitative Land Cover	13	15	24	14	28*	31
Quantitative Land Cover	10	15	25	12	30*	33
Biometry	N/A	5	12	N/A	17	20
MUC System	N/A	8	13	N/A	15	18
Land Cover Mapping	6	9	16	10	16	18
Accuracy Assessment	4	4	10	3	12	14
Sample sizes:	97 ≤ n ≤ 70	n = 93		93 ≤ n ≤ 109	116 ≤ n ≤ 120	

†In the Year 5 survey, teachers were asked if the protocol was implemented by: the teacher, the teacher and another teacher, or solely by another teacher or teachers in the school. The "School" response column counts a response to any of these categories as being implemented in the school.

* Difference between Y3 and Y5 respondents significant at p < .05

Soil. The implementation rates in Year 5 for Soil protocols showed the most dramatic increase in comparison to Year 3 implementation rates. Many of the Soil protocols—namely, Soil Characterization Laboratory Analysis, Gravimetric Soil Moisture, Gypsum Block Soil Moisture (not recommended for elementary level) and Infiltration protocols—were not implemented by recently trained teachers at all at the elementary level during Year 3. For many of the individual protocols, the Year 5 rates are an increase of several fold over Year 3. The general pattern of protocol implementation we see for Soil protocols between Years 3 and 5 shows individual teachers implementing protocols at a higher rate ("Self" category) in Year 5 and school-wide implementation rates ("School") higher than individual implementation in this year. For example, for Soil Characterization Lab Analysis, the middle/secondary implementation rate increased from 8% to 28% between Years 3 and 5, and school-wide implementation in Year 5 is reported at 36%, as shown in Table 4.16.

Table 4.16
Soil Protocol Implementation, by Year 3 and Year 5 Trained Teachers (Percent Reporting)

Protocol	*Elementary*			*Middle/Secondary*		
	Y3 Trained Teachers	*Y5 Trained Teachers*		*Y3 Trained Teachers*	*Y5 Trained Teachers*	
	Self	*Self*	*School†*	*Self*	*Self*	*School†*
Soil Characterization Field Measurements	3	18*	26	17	30*	40
Soil Characterization Lab Analysis	0	15*	22	8	28*	36
Gravimetric Soil Moisture	0	4	12	3	14*	18
Gypsum Block Soil Moisture	0	2	9	4	7	10
Infiltration	0	9*	16	5	25*	31
Soil Temperature	2	13*	22	6	32*	39
Sample sizes:	64 ≤ n ≤ 66	91 ≤ n ≤ 94		104 ≤ n ≤ 110	117 ≤ n ≤ 129	

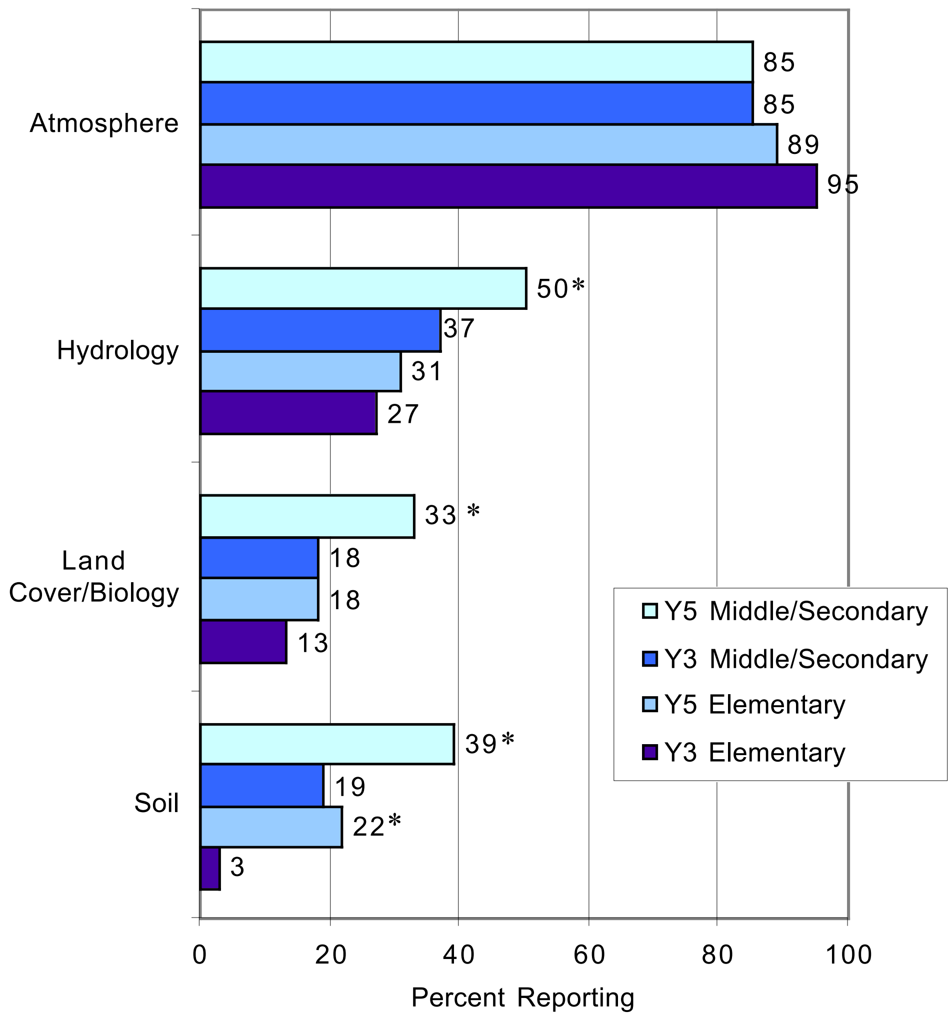
†In the Year 5 survey, teachers were asked if the protocol was implemented by: the teacher, the teacher and another teacher, or solely by another teacher or teachers in the school. The "School" response column counts a response to any of these categories as being implemented in the school.

* Difference between Y3 and Y5 respondents significant at $p < .05$

Summary of Trends for Protocol Implementation

After examining implementation rates for individual protocols, we determined for each Year 5 survey respondent whether that person implemented one or more of the data collection protocols in each GLOBE investigation area. The results are shown in Figure 4.7. As the figure shows, while implementation rates between Years 3 and 5 held steady for Atmosphere protocols (the drop in implementation at the elementary level was not statistically significant), there is an increase in implementation rates in the three other investigation areas. For Land Cover/Biology and Hydrology, the increases were significant at the middle/secondary level. For Soil protocols, they were significant at both grade levels (from 3% to 22% at the elementary level, and from 19% to 39% at the middle/secondary level).

Figure 4.7
Implementation of GLOBE Protocols by School Level for Year 3 and Year 5



Sample sizes: Y5 Middle/Secondary 107 ≤ n ≤ 130, Y3 Middle/Secondary 110 ≤ n ≤ 116, Y5 Elementary 94 ≤ n ≤ 107, Y3 Elementary 67 ≤ n ≤ 74

* Difference between Y3 and Y5 respondents significant at $p < .05$

Overall, the data shown in Figure 4.7 suggest that implementation of GLOBE protocols is becoming more balanced across the four investigation areas. The modest decrease in implementation rates for Atmosphere protocols occurs in the context of significant increases in implementation rates for protocols in the other investigation areas.

Learning Activities

Current Practices

GLOBE learning activities, which are intended as a supplemental feature of the GLOBE Program, continued in Year 5 to play an important role in GLOBE classrooms. Teachers implementing one or more GLOBE protocols in an investigation area generally implemented learning activities at a similar or even higher rate. The similarity between rates of protocol implementation and rates of implementation of GLOBE learning activities suggests a complementarity between these aspects of the GLOBE Program—that is, teachers see both protocols and learning activities as integral parts of participation in GLOBE.

Figure 4.8 shows the recently trained and active teacher reports of implementation rates for learning activities by grade level and investigation area in Year 5. Soil and Land Cover/Biology learning activities are implemented at the lowest rates, and Atmosphere learning activities are implemented at the highest rates. Active teachers at both the elementary (94%) and middle/ secondary (85%) levels implement Atmosphere learning activities at significantly higher rates than trained teachers (84% and 75%, respectively). In comparison, 98% of active elementary teachers, as shown in Figure 4.6, implement one or more of the Atmosphere data collection protocols. Elementary teachers implement learning activities at rates higher than middle/secondary teachers only within the Atmosphere investigation area. For the three non-Atmosphere investigation areas, rates of learning activity implementation, like those of protocol implementation, tend to be higher for middle/secondary teachers.

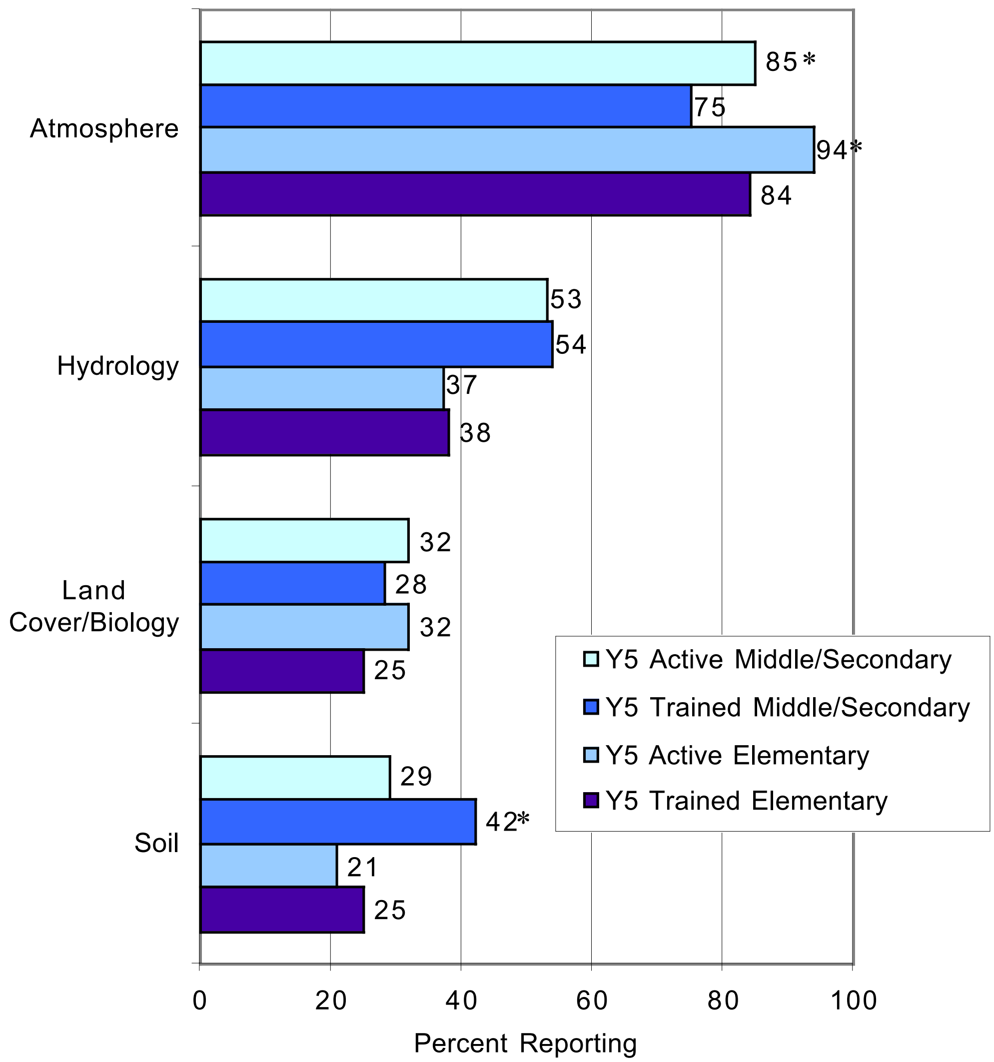
Notably, for the Soil investigation area the learning activity implementation rate is higher for recently trained middle/secondary teachers than for active teachers. Soil is also the one area in which protocol implementation rates are higher for recently trained than for active teachers, as discussed above. At the elementary level, 25% of trained teachers implemented one or more Soil learning activities compared to 21% of active teachers. At the middle/secondary school level, the difference is significant with 42% of trained teachers implementing one or more Soil learning activities in comparison to 29% of active teachers.

Trends

The implementation rates for learning activities in the three non-Atmosphere investigation areas increased between Years 3 and 5, as shown in Figure 4.9. This increase is greatest at the middle/secondary school level, and is particularly significant for the Soil investigation area. Implementation rates for trained teachers implementing

Soil and Hydrology learning activities at the middle/secondary level jumped significantly between Year 3 and Year 5. For Soil, the learning activity implementation rate rose from 20% in Year 3 to 42% in Year 5. For Hydrology, it rose from 37% to 54%. These data suggest that learning activities are becoming a more valued part of the GLOBE Program.

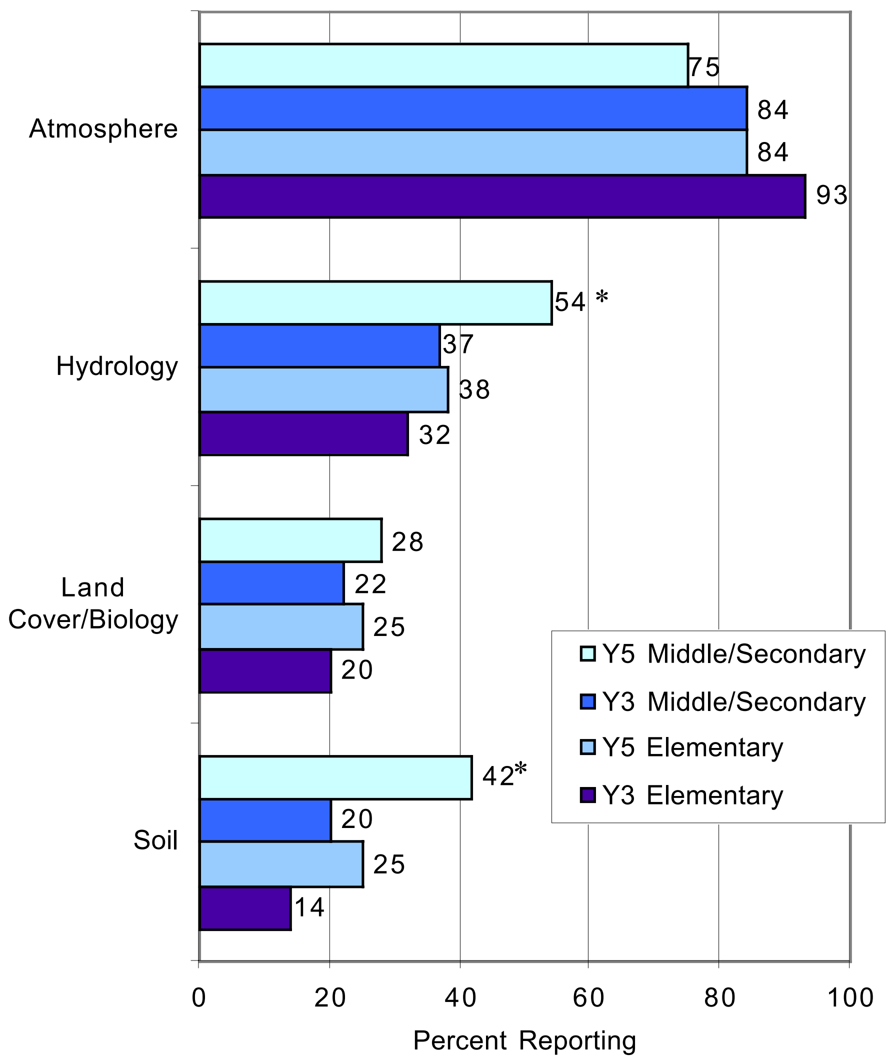
Figure 4.8
Implementation of Learning Activities by Year 5 Trained and Active Teachers



Sample sizes: Y5 Active Middle/Secondary 227 ≤ n ≤ 255, Y5 Trained Middle/Secondary 131 ≤ n ≤ 138, Y5 Active Elementary 155 ≤ n ≤ 171, Y5 Trained Elementary 101 ≤ n ≤ 106

* Difference between trained and active respondents significant at $p < .05$

Figure 4.9
Implementation of Learning Activities,
by Year 3 and Year 5 Trained Teachers



Sample sizes: Y5 Middle/Secondary $131 \leq n \leq 138$, Y3 Middle/Secondary $107 \leq n \leq 116$, Y5 Elementary $101 \leq n \leq 106$, Y3 Elementary $64 \leq n \leq 72$

* Differences between trained and active respondents significant at $p < .05$

In general, trends in the implementation patterns of learning activities roughly parallel those of implementation trends for data collection protocols. Implementation rates for learning activities in the Atmosphere investigation area appear to have dropped slightly, but not significantly so, while rates in the other areas, particularly Soil, have increased. Most of this change seems to be attributable to recently trained teachers, who are concentrating on the non-Atmosphere investigation areas more than their counterparts trained earlier did.

Factors in Selection of Protocols and Learning Activities

Current Practices

Teachers in our samples were asked in an open-ended survey item to explain the three chief factors leading them to implement certain protocols and learning activities and not others. Table 4.17 summarizes our analysis of trained and active teachers' responses. As the table shows, both groups of teachers made selections among protocols and learning activities for similar, largely pragmatic reasons. Nearly two-thirds of the reasons cited by trained and active teachers for choosing protocols fit into the broad category "Ease of implementation" (61% and 62%, respectively). Similarly, about half of the reasons trained and active teachers cited for choosing learning activities fit into this category (49% and 47%, respectively). "Ease of implementation" subsumes a number of more specific subtypes, including reasons that relate to the relatively small amount of time required for some protocols and activities, the ready accessibility of data collection locations, and the lower cost of materials, among other practical considerations.

Although trained and active teachers overall cited reasons related to ease of implementation at approximately the same rates, there were some notable differences between the two groups for the most frequently cited specific subtypes. Recently trained teachers cited time considerations somewhat less frequently than active teachers (17% v. 24% of reasons for choosing protocols, and 18% v. 24% of reasons for choosing learning activities), and they cited equipment or materials considerations somewhat more frequently (11% v. 8% of reasons for protocols and 13% v. 8% of reasons for learning activities). These differences in the data suggest that many recently trained teachers might still be in an initial planning and set-up phase with regard to implementation, and are more involved in developing the materials, sites, and ability to execute protocols and activities than active teachers. Active teachers, it may also be inferred, have secured many of the basics for implementation, and now are confronted primarily by the challenge of finding adequate time to do protocols and learning activities with their students.

Second to ease of implementation, teachers most frequently cited reasons for implementing particular protocols and activities that related to how well these fit within the existing or mandated curriculum and how well they matched students' level of interests. Trained teachers were somewhat more likely than active teachers to identify curriculum fit as a factor in their choice of protocols (16% v. 12%), and both sets of teachers

Table 4.17
Trained and Active Teacher Reports of Factors Determining Their Choice of Protocols and Learning Activities for Implementation (Percent Reporting)

Factor	Protocols		Learning Activities	
	Y5 Trained	Y5 Active	Y5 Trained	Y5 Active
Ease of implementation	61	62	49	47
Minimal time requirement	17	24	18	24
Availability of equipment/materials	11	8	13	8
Convenience of location/lack of transportation requirement	12	10	5	4
Ease of protocol procedures	10	9	6	5
Low cost	3	2	1	1
Ease of class/group management for this activity	2	2	1	1
Availability of support from other school staff	3	3	2	2
Weather/other geographic constraints	3	4	3	1
Curriculum fit	16	12	21	18
Match to students' level/interests	10	12	12	12
Familiarity/clarity of procedures	7	7	7	7
Quality of content	5	6	6	10
Conceptual support for protocols	N/A	N/A	5	5
Other	1	1	0	1
Number of responses:	n = 597	n = 1072	n = 430	n = 748

cited curriculum fit as a major factor in their choice of learning activities, with a slightly higher rate for trained teachers (21% v. 18%). The match between the protocol/activity and the level or interest of students was the third most frequently cited selection criteria for both trained and active teachers, who cited this reason at a similar rate (10% v. 12% for protocols and 12% for both samples for learning activities). Teachers' familiarity with or evaluation of the clarity of the protocols/activities was another, less influential, factor in teachers' selections, as was the quality of the content of particular protocols or learning activities. Trained teachers were less likely to cite quality of content as a rationale for selecting learning activities (6% v. 10% for active teachers). Five percent of reasons cited by trained and active teachers indicated that they chose learning activities as conceptual supports for the protocols they were implementing.

Overall, both sets of teachers seem to select protocols and learning activities by considering the feasibility, the effort, and the time required for each alongside the likely benefits to students in their classroom. A look at the discrepancies between trained and active teachers suggests that issues tend to take on more or less importance in teachers' thinking at different stages of program adoption. Early on, teachers worry about having access to an appropriate field site and the right equipment. Later on, they are more likely to be driven by considerations of the time required for an activity or measurement.

Trends

When the responses of trained teachers in the 2000 survey (described above) were compared with the responses of teachers in 1998, we found marked stability in the reasons cited across the two years. For example, 61% of reasons for protocol selection cited by trained teachers in Year 5 and 62% cited in Year 3 related to ease of implementation. For learning activities, 49% of the reasons cited by both groups of teachers fell into this category.

Perceived Challenges for Teachers Implementing GLOBE

Current Practices

In addition to asking teachers about influential factors in their choice of protocols and learning activities, we also asked teachers who had implemented GLOBE to respond to a survey question regarding barriers that prevented them from implementing additional protocols. As shown in Table 4.18, trained and active teachers reported the same top three barriers at nearly identical rates. For both groups of teachers, the means to collect data on weekends, the time to prepare, and the time to complete GLOBE activities within their school schedule stood as top challenges to broader implementation of the program. Trained and active teachers both ranked time away from mandated material as the next most serious barrier.

Comparing the two Year 5 teacher samples, the biggest differences in responses to this survey question relate to practical problems with technology and data collection sites. Trained teachers were more than twice as likely as active teachers to report that they felt impeded by lack of Internet access (25% v. 11%), lack of computer hardware/software (19% v. 8%), and difficulty identifying appropriate sites to take measurements (19% v. 8%). Trained teachers were almost three times as likely to report that they felt impeded by lack of technical support (22% v. 8%).

Table 4.18
Problems Rated as “Major Barriers” by Trained and Active Teachers Implementing GLOBE with Students

Barrier Rated as “Major"	*Y5 Trained*	*Y5 Active*
Lack of way to collect data on weekends	53	53
Difficulty finding time to prepare	45	44
Difficulty completing activities within school schedule	35	35
Time away from mandated material	28	33
Difficulty integrating GLOBE into curriculum	18	21
Lack of Internet access	25*	11
Lack of computer hardware/software	19*	8
Difficulty identifying appropriate site to take measurements	19*	8
Lack of tech support	22*	8
Concern if GLOBE is valuable for students	2	2
Sample sizes:	247 ≤ n ≤ 262	420 ≤ n ≤ 440

These findings, taken together, indicate that trained teachers who are implementing GLOBE face more barriers to broader implementation than active teachers. From the data, it appears that active teachers have overcome many of the difficulties associated with technology, materials, and the establishment of sites for data collection, but that they do not have the time to engage in additional activities. Recently trained teachers are also constrained by the same time factors, but they are also confronted by other difficulties, including those associated with technology.

Discussion

The differences between recently trained and active teachers for the data reported in this chapter reflect the way the two samples were defined. The active teachers’ schools were, by definition, above-average in their levels of data collection and reporting. Recently trained teachers implementing GLOBE with students, by contrast, were participating in the program at the widest possible range of levels—from the most minimal levels of involvement to levels comparable to those of the highly active teachers. Being newer to the GLOBE Program on average, recently trained teachers confronted many obstacles that active teachers had already overcome: getting an Internet connection, identifying sites for data collection, securing the necessary equipment, and so on.

While more varied than active teachers in the extent and nature of their involvement, recently trained teachers have brought something important to the success of the GLOBE Program. Newly trained teachers are rounding out the program, adding to their schools' GLOBE programs previously under-implemented activities in the Soil and Hydrology investigation areas (areas where they are more likely than active teachers to be implementing many of the protocols). Recently trained teachers also seem to regard GLOBE learning activities as a core part of the program (75% of teachers implementing the program are using them), and are as likely as active teachers to implement them.

The complementarity we see developing at a school-wide level between more seasoned GLOBE teachers and their newer counterparts fulfills many of the expectations of the GLOBE Program and extends trends noted in earlier reports. Our survey data confirm that with time GLOBE is being established as a multifaceted educational resource for teachers in addition to serving its important scientific purposes. With more multi-teacher schools, more depth of GLOBE practice, and more resources readily available to teachers who want to use select parts of the program, GLOBE is developing the broad influence that was its past potential. The multi-teacher model seems to be the most promising—and likely—way to address the pervasive problem of time shortages that most teachers report facing. Even with more stringent curriculum standards and testing mandates, a highly diversified GLOBE program will find the most likely fit in contemporary classrooms.

Chapter 5. Classroom Case Studies

Two key areas in which GLOBE program staff are working to improve program effectiveness are broadening GLOBE's base within participating schools and helping teachers incorporate scientific inquiry skills into the teaching of GLOBE. In this year's field work, SRI studied selected schools that have begun to teach scientific inquiry skills and have been successful in their own schools in expanding the reach of GLOBE beyond a single classroom. In selecting these schools, we sought to understand how successful GLOBE teachers achieve these goals and surmount the kinds of challenges reported by teachers who have had GLOBE training, but achieved more limited implementations (see Chapter 4). Low-implementing teachers express concerns about aligning GLOBE with state and local curriculum standards, finding time to plan for GLOBE and use it in the classroom, and finding ways to adapt the program to the needs of students who are not naturally inclined toward science or academic subjects. At each of the schools we visited, we found teachers who perceived or made connections between GLOBE and standards, who found creative ways to carry out GLOBE activities with limited time, and who adapted GLOBE to their local environments in ways that captivated student interest.

For our case studies, we conducted site visits during the 1999-2000 school year to five schools that had demonstrated high use of GLOBE and incorporated elements of student inquiry and investigation into their GLOBE activities. During these site visits, we observed GLOBE data collection and related classroom activities. We talked with teachers about their goals for student learning, their classroom management strategies, and their perceptions of the major barriers to GLOBE implementation. We also interviewed GLOBE-trained teachers at the same schools who were not implementing the program to understand their perceptions of the program. We talked with principals and U.S. partner coordinators about the differences they observed between teachers who adopted GLOBE wholeheartedly after training and those who barely used it. In this chapter, we interpret these findings and discuss the major themes that emerged from these interviews.

Through the process described in Chapter 2, five sites were selected for the case studies: (1) Guillen Middle School in El Paso, Texas; (2) Harbor Beach High School in Harbor Beach, Michigan; (3) Middleport Elementary School in Middleport, New York; (4) Gold Dust Elementary School in Phoenix, Arizona; and (5) Kingsburg High School in Kingsburg, California. The schools were selected from a list developed through recommendations by U.S. partner coordinators and teachers. The final sample represented different geographic regions, grade levels, and demographic profiles.

Our interviews and observations revealed several common themes that helped these teachers achieve success. First, all of these high-implementing teachers described having strong support from their local administrators, often in the form of supplementary funding or additional technology. Second, all teachers described organizing data collection around local environmental issues, a practice that appeared to stimulate interest in scientific inquiry. Third, school staff expanded GLOBE within their own schools by developing creative strategies for involving other teachers in aspects of GLOBE implementation. Fourth, all of these teachers demonstrated creativity in managing their classrooms, finding a variety of ways for students to participate in multiple aspects of scientific inquiry, from data collection to analysis and reporting.

Nurturing Innovation: Administrative Support

Across all five case study schools, we discovered that high-implementing GLOBE teachers benefited from having strong support from a local administrator, usually the principal. Principals provided fiscal support for training and transportation to data collection sites as well as material support for purchasing equipment. They also provided moral support by communicating with the primary GLOBE teacher frequently, praising the teacher's efforts, and following the teacher's lead on implementing the program. In Kingsburg, the principal and lead GLOBE teacher worked together as a team to troubleshoot problems. The school principal put it best:

> *Our support is not very strong financially because of budget constraints. However, the administration allows teachers a lot of latitude and lets teachers run with their ideas—experience their own ingenuity. We allow the release time necessary to let the teachers work together collaboratively. … Our attitude is: Tell us what you want to do, we'll give you the time, the release to do it, and support the innovation to get it done. Teachers flourish under this system.*

A similar attitude existed at Harbor Beach and Phoenix, where money was tight, but the principals still found ways to cover most GLOBE expenses. At Harbor Beach, principal Skip Kadar made sure students had extensive technology access. Every classroom in the building was wired, and each had at least one or two computers connected to the Internet. The library had several computers, and there were two computer labs with up-to-date Windows-based machines. To raise money for new technology, Kadar has also instituted a program to re-sell old computers to the community for $20 to $30 apiece. Kadar has also found funding to cover GLOBE teacher Linda Lenar's travel to GLOBE training and conferences.

In Phoenix, principal Marian Hermie financed two trips over four years for special GLOBE training for teacher Sue Robinson, using Eisenhower grants. The school board has also used Eisenhower grants to finance training for teachers at a nearby school. Robinson fostered the board support by having her elementary students make a 20-minute presentation in which they demonstrated their expertise in using thermometers and mathematical computation.

> *And when we got all finished, Dr. Dewers, our superintendent said, "Do you know what kind of higher math they were doing? And I actually think they knew what they were talking about!" He was blown away too. And so that's where our support came from then: the school board and the superintendent.—Sue Robinson, GLOBE Teacher*

Principals at nearly all the schools supported the program by treating it as a special asset that set their schools apart from other schools, telling parents and school board members about the program's hands-on science approach and its focus on getting students involved in the local community. Principal Jackie Peffer started in Middleport in the past year, and has dedicated herself to promoting GLOBE to the school board and public. "The community can see what the kids are doing," she said. Such support allows her to obtain district funding for GLOBE to help pay for program implementation.

Even these supportive principals face challenges in promoting GLOBE use in their schools, however. Principal turnover is frequent, and new principals are reluctant to come into a school environment and impose new programs on longtime teachers. Skip Kadar at Harbor Beach said, "It's one of those things you have to want to do it to do a good job. I'm not going to say, 'You will do this.' But if we were to have a retirement on staff in the science department and we brought a new person in, I would make that part of the program." Middleton's Peffer also expressed some doubt that her efforts to "push" GLOBE could inspire teachers at the nearby junior high school to adopt the program. In the meantime, she praises GLOBE teacher Gail Fuller's efforts to bring the graduates of her elementary class back to work on GLOBE projects once they enter junior high. "The kids have really come back from the junior high, and they really have come back and worked on major projects with her. That's the carry-through. We want kids to be able to remember what they've done," Peffer said.

Arkansas GLOBE U.S. partner coordinator Lynne Hehr has thought systematically about the barriers teachers face when trying to implement GLOBE. She also has noticed that many teachers returned to school only to encounter lack of administrative support. To address this problem, Hehr began requiring each GLOBE training applicant to obtain their principal's endorsement and promise to provide support, particularly Internet access, in their application.

The importance of such support was reflected in the expressions on the teachers' faces as they discussed administrators who had found funding for GLOBE or who publicized the program's successes. The support lets these teachers make GLOBE happen. Linda Lenar, a teacher from Harbor Beach, said, "You need support from the administration that lets me do these things, that let me take students places."

Good Local Adaptation: Local Environmental Issues

One of the consistent strategies for stimulating inquiry in GLOBE lessons is to organize data collection around local environmental priorities. Across all five sites, the teachers were aware of local environmental issues and interested in scientifically documenting them. In El Paso and Harbor Beach, teachers focused on GLOBE Hydrology measurements because of concern over potential contamination of local water sources. In Middleport, the acidity of the rainfall was a concern because of the school's proximity to a coal-burning power plant. In Phoenix, biometry was used to study the impact of freeway air pollution on local plant life. In Kingsburg, students investigated ozone levels to document the flow of pollution from San Francisco to the San Joaquin Valley. The teachers did not limit their data collection to such environmental concerns, but used these local references to supplement the general data collection procedures.

Some teachers have established collaborations between GLOBE and local and state organizations that can use the scientific data to make policy decisions. In Harbor Beach, for example, the GLOBE teacher was approached by attorneys for citizens concerned about monitoring the impacts on local waterways of new sewage treatment ponds. The nearby town of Forestville was planning to build two large lagoons for storage of human waste. The waste would be emptied one to two times per year into nearby Wanke Creek. A lawyer representing some residents of Forestville contacted Linda Lenar and invited her and her students to begin monitoring Wanke Creek. Students began data collection almost immediately, picking three sites and checking a number of indicators of water quality, many of which were measured using GLOBE protocols. Two years later, the lagoons were finally approved on the condition that the students' monitoring of the creek would continue. By then, students had a good baseline from which they could determine whether water quality was improving or getting worse at Wanke Creek. The legal agreement paved the way for the town of Forestville to purchase hydrology equipment for the school. These students learned both science and lessons about the role of scientific data in policy debates and negotiated agreements. For example, the students understood that their data were confidential.

Exhibit 5.1
Guillen Middle School Students and Their Teacher, Lee Bondurant, Collecting Water Samples from Franklin Canal Near the Rio Grande in El Paso, Texas

Such collaborations have also sprung up in Arizona, where water resources are a critical concern. Arizona educators are collaborating with Project WET (Water Education

Teachers), Hands Across the Border, and Water Watch, for example, according to GLOBE Soil Moisture scientist Jim Washburne of the University of Arizona, Tucson.

There are some indications that focusing on local environmental issues stimulates an interest among teachers to collaborate with other schools. Because environmental issues do not respect school attendance area borders, GLOBE teachers focusing on these issues are motivated to recruit colleagues from other schools in the impacted area. To expand her freeway pollution study, for example, Sue Robinson in Phoenix contacted several other GLOBE-trained schools to see if they would work with her. Lee Bondurant in El Paso has identified two other Hydrology sites that may provide interesting comparison data for her students, and said that she too would like to find other GLOBE schools that would be willing to collaborate with her on a project. Fostering such collaboration is another important theme among high-implementing GLOBE teachers.

Strategic Outreach to Other Teachers

These GLOBE teachers all expressed the desire to connect more with other teachers as part of GLOBE. All had actively recruited colleagues to the program, often developing a range of ways for them to help out, depending on their interest level and commitment. The success of such outreach was more often than not associated with a collegial spirit in the school. For example, teachers in Sue Robinson's school in Phoenix had participated in a program geared toward fostering collaboration across classrooms, and this set the stage for Robinson to teach GLOBE as a visiting teacher to other classes. In Kingsburg, the high school science department chair served as a GLOBE curriculum leader, and so she used her role to start several colleagues in the program.

These teachers' desire to connect with colleagues is relatively commonplace across educational reform efforts, according to GLOBE U.S. partner coordinator Lynne Hehr, based at the University of Arkansas, Fayetteville. Hehr, who has raised the level of GLOBE implementation in her program by identifying and addressing barriers to implementation, noticed early on that many schools were sending just one teacher to GLOBE training sessions. When these teachers returned to school after GLOBE training, they often drew criticism from peers or became overwhelmed about where to begin. To prevent such problems, Hehr began requiring teachers to assemble a GLOBE team before accepting them to training. She has encouraged teachers to collaborate with colleagues across disciplines rather than seeking out only science teachers.

However, the teachers at the five case study schools had all been early adopters of GLOBE and had not been part of such a team. Consequently, they had to use their ingenuity to reach out to colleagues at other grade levels and in other subject areas and schools. In Harbor Beach and Kingsburg, high school teachers trained elementary classrooms to collect data, and these students' datasets would then be available to the high school students for analysis. The Harbor Beach teacher also used what in the business world might be called an "outsourcing" approach to teacher outreach, asking the geometry teacher to have her students make clinometers for GLOBE classes as part of their beginning trigonometry unit. In this case, the mathematics teacher's students often took the environmental science class the subsequent year, and so these students could become "trainers" for their peers in tree biometry when they entered her class. A couple of the teachers spoke of trying to appreciate the different "passions" and "interests" of colleagues, and how they tried to match some aspect of GLOBE—no matter how small—to these inherent passions and interests.

One way to spur interest among colleagues is to show how GLOBE aligns with local curriculum standards. In today's high stakes educational environment, where standardized testing, curricular reform, and accountability are predominant themes, teachers are increasingly concerned about meeting performance expectations in a prescribed time frame. In our interviews with GLOBE-trained teachers who do not implement the program, we found that competing priorities and curricular standards are regarded as a barrier to implementation.

> *We don't have the time to devote to it. If we did devote time to it, we would have to cut out other units that we are required by law to teach to the children. I think it could work if we still had the science the way it used to be. It used to be physical science 6th grade, life science 7th grade, earth science 8th grade. Right now we have to do little units in everything. Force and motion. Human body. In order for GLOBE to work, we need to have the kids take the time to learn how to use the systems, how to use the equipment, and you have to take the time to do the reading, to do the different things.*

While some teachers view content standards as incompatible with implementing GLOBE, others are finding that standards can help the program. One of the more successful ways to involve more colleagues occurred when a lead GLOBE teacher used her knowledge of curriculum standards to show how the program could be integrated into multiple subject areas. Sue Robinson in Phoenix identified the types of GLOBE lessons that aligned with standards, and then offered to conduct lessons that fit into the teachers' classes. After her colleagues observed her lessons, some of them took over, incorporating GLOBE activities into their own curriculum.

> *What I did was to take the state standards and the national standards in math, science, reading, language and all of that and I looked at what parts of the GLOBE training could be used in all of those areas, specifically in math and science. Those were the two easiest to start with. And I found out that they hit so many of the different grade levels.*

Robinson came up with a list of lessons tailored to each grade. Third-graders were learning to read thermometers, so she used GLOBE for that lesson. Fourth-graders were learning division, decimals and percentages, an easy match to the use of these concepts in GLOBE data reporting forms. Fifth-graders were mastering decimals and percentages, so she focused on studying percentage of ground cover and foliage of trees. Sixth-graders were studying the countries of the world, so she got them involved in using GLOBEMail.

Harbor Beach teacher Linda Lenar achieved similar success in outreach with a slightly different approach at her former elementary school in Caseville, Michigan. "We had it so that every grade took one protocol. One did Temperature. One did Precipitation. One did percentage of Cloud Cover. One did Cloud Type. One did pH in the water. We have everyone involved. I think you've got to pull together," Lenar said.

Most of the GLOBE teachers in the case study got involved in outreach on a larger-scale level too, working as trainers or spokespeople for U.S. partner training programs. Where no U.S. partner was present, these teachers took the lead in fostering local training efforts. The Harbor Beach teacher, for example, used a school videoconferencing system to train GLOBE colleagues at other schools in the Michigan "Thumb" region. Her efforts were focused on teachers who had been trained in GLOBE but were not implementing it as well as on teachers who had never learned about GLOBE. There were four other GLOBE schools nearby and each was connected via a videoconferencing system with locations in Caseville, Bad Axe, and North Huron. Lenar led an after-school session with teachers, showing them different aspects of the GLOBE Web site, including logging on, entering data, using GLOBEMail, viewing other schools' data, and visualizations. Lenar described it as a type of refresher course that would familiarize teachers with the technological aspects of uploading data on to the GLOBE site.

These findings suggest some creative ways that active GLOBE teachers have developed to garner collegial support for their activities. Such support not only reduces teachers' isolation from one another, but it also expands GLOBE within schools to create a cadre of teachers who are engaged in a common project with their students. If one teacher is facing a problem implementing GLOBE, he or she does not have to wait to talk to a GLOBE trainer but can consult a colleague down the hall. And if one classroom has a conflict precluding measuring rainfall one day, another classroom may be able to take the measurement and ensure that the school has a consistent data set with no interruptions.

Creativity in Classroom Management

Some trained teachers who do not implement GLOBE believe that the program appeals only to students interested in science or that it is too difficult to manage with a large class. Both of these concerns relate to classroom management.

> *The reason I'm not using it is because my class is so big. Twenty or thirty kids. I just can't. If I had smaller classes I might be able to use some of it. I'm not going to take that many kids out there.*

> *I think it could be used with a particular kind of student. I don't think it's geared for every kind of student. I think they need to have someone who's really interested in science.*

The active GLOBE teachers in the case study did not share these perceptions. They developed ways to manage the program so that it could work with a wide variety of students and large groups. They also consistently found ways to expand and deepen GLOBE implementation well beyond the collection of Atmosphere protocols. All these teachers involved their students in data collection that followed multiple protocols.

Classroom management seems to be the critical factor distinguishing teachers who pursue only Atmosphere protocols and those who pursue multiple protocols. As typically implemented, Atmosphere protocols represent a task that requires relatively little complex classroom management. Students go in small groups each day to a site on the school grounds, usually at the beginning or end of a class. This activity requires little organization or planning beyond initial training in the data collection protocols and setting up a scheduled rotation among students. To manage the simultaneous implementation of multiple protocols in classes of varying sizes and with students of varying skill levels, teachers at the five case study schools needed to use more creativity in classroom management.

Their creative management strategies enabled teachers to involve larger groups of students in multiple data collection tasks off site. Teachers were also able to distribute the responsibilities for teaching among the students, giving students a larger role in directing their own learning. When students assumed more of the responsibility for learning, teachers could respond flexibly to the different needs and abilities of students in the classroom.

Our interviews revealed three primary approaches to classroom management employed by these GLOBE teachers: data collection planning and task distribution, leveraging student expertise, and scaffolding scientific inquiry.

Data Collection Planning and Distribution

By devoting more class time to planning and task distribution, these GLOBE teachers could engage their classes in more complex activities, such as off-site data collection and GLOBE online chats. During these planning sessions, teachers would distribute data collection chores among the class members, broadening the amount of data a single class could collect. These teachers took pains to prepare students ahead of time for the various steps in each innovative GLOBE activity. For example, in Kingsburg, students prepared ahead of time for a GLOBE chat with students in West Virginia. With the assistance of their teacher, they anticipated possible questions, then typed up some prepared text focused on data so they could quickly cut and paste comments during the actual chat session. The next day, during the chat, the teacher did not need to spend all her time monitoring the chat. She merely stopped by to make sure students focused on data as much as on social interaction.

In El Paso and Middleport, the teachers devoted class periods to both training and organizing students into data collection groups. Students received specific jobs in the data collection process, from handling particular instruments to recording the findings. During actual data collection, both teachers floated from group to group, while students took the lead. The teachers spent their time monitoring students in the various groups, making sure that procedures were being followed and answering questions. In Harbor Beach, the high school teacher assigned various groups in her environmental science class to continuing data collection jobs: biometry, budburst measurement, and soil analysis.

Exhibit 5.2
Middleport Elementary Teacher Gail Fuller Prepares Fifth- and Sixth-Grade Students for Data Collection Jobs

Leveraging Student Expertise

These GLOBE teachers found ways to cultivate and tap student expertise, empowering students to take responsibility for many aspects of GLOBE. Students in these classes assumed responsibilities for training peers or younger students in data collection protocols. This type of management practice facilitated such innovative uses of GLOBE as cross-age collaboration and multiple types of data collection in a single class. In our case study sample, the students assuming these responsibilities were in high school, although there was some peer mentoring occurring on simple protocols among elementary students in Middleport too. In Harbor Beach, the high school was located near the elementary school so the teacher arranged for high school students to bring along elementary students each day to collect Atmosphere data. The high school students described how they explained details about data collection to the younger students, such as taking the temperature from the bottom of the meniscus. In addition, the high school students monitored how accurately the elementary students were recording the data posted to the GLOBE Web site. The same teacher has encouraged her independent study students who excel in science to take on some of the work for training their peers in specialized data analysis, such as use of MultiSpec. In Kingsburg, teacher Peggy Foletta set up a collaboration between her students in the San Joaquin Valley and elementary students located in Yosemite, a distant data collection site visited by the San Joaquin students every other year. Foletta's students taught the elementary students about GLOBE and data collection.

In Phoenix, elementary teacher Sue Robinson found that such collaboration helps students appreciate the diverse skills of their peers. She has found that GLOBE is rich enough to permit students who would not normally be considered the "smart" ones to shine in some way. She found that students who did not excel at reading, for example, suddenly had the opportunity to reveal their expertise and knowledge about natural phenomena. GLOBE has become a confidence-builder for these students, giving them the experience of feeling accomplished in science. She said that junior high and high school teachers come back and tell her that her former students are not afraid to approach any of the scientific subjects.

> *You would think it would be the honors, the gifted students who would excel. Not necessarily! … The kids then would see that that child, whom they had previously thought was very dumb because she failed every single reading and writing assignment—they began to see her as a smart person. And so that's another beauty of GLOBE, is that it brings out.*

Middleport teacher Gail Fuller found similar success with her multi-age inclusion class. Most of the 27 students in her class are diagnosed with some type of behavioral, emotional, or intellectual disorder. One of her most reliable students for uploading data to the GLOBE Web site has a behavioral disorder. During observations of her class, the diversity of student skills was apparent, with some students assuming the role of teacher and leader, and others struggling to work out basic social interactions. All students found meaningful roles within the class' GLOBE activities, however, and random interviews with the students revealed that most of them could articulately discuss the protocols and the insights these protocols gave scientists into the environment.

Scaffolding Scientific Inquiry

To varying degrees, all these GLOBE teachers coached students in some aspects of scientific inquiry. Behind each teacher's coaching lay a deep belief in the value of involving students in data collection and "real science." These teachers' beliefs provide as the basis for their support of data-driven scientific inquiry in the classroom.

> *Kids like doing real science. They enjoyed having online chats with the scientists and they like having science projects that change over time.—Lee Bondurant, Guillen Middle School teacher*

Sue Robinson of Gold Dust Elementary also emphasized the importance of experiential learning as a way to make unfamiliar concepts—such as metric measurement—second nature to students. "You know, they'll look at something in the room and they'll say, 'Oh, I don't think that's a meter.' Because they've measured trees and they'll say, 'Oh, that tree is five meters tall.' And they can see, they've seen a tree that's five meters," she said. Linda Lenar of Harbor Beach High School said that carrying out the GLOBE protocols made her students more careful when conducting laboratory research. With traditional labs, she observes, students become sloppy, because the data don't have any real meaning for them. GLOBE is a not a "canned" lab, so students take it more seriously and have learned about the importance of accuracy in data reporting.

Motivated by these beliefs, each of these teachers has found ways to scaffold a data-driven scientific inquiry process. All the teachers coached the students in collecting data accurately and in using scientific terms while they collected data. Peggy Foletta of Kingsburg High School explained the term "ground truthing" to students embarking on the process of identifying tree species. She said the process verifies and enriches the information scientists have from satellite imagery. Some teachers focused on more conceptual processes of data analysis and the formulation of a research question. Sue Robinson had attended a special GLOBE conference and was surprised to learn that scientists work in an iterative process to develop their research questions, usually with much critique from their peers along the way. She already was helping her students to pose questions about their observations and to think about confounding data that could explain some of their findings. The goal was to "interpret the data and articulate the big idea or trend," she said. In the future, she plans to delve deeper into the process of research development, using GLOBE.

Gail Fuller helped her students look for trends in data by lining up graphs side by side.

"Give me a big general idea, not a detail," Gail would tell students.

The students worked in groups, reviewing three charts they had drawn for homework that showed the daily shifts in pH data, amount of rainfall, and temperature over one month. They were asked first to make a general statement about pH levels. Fuller gave the students a “hint” after they worked for a bit on their own: “You might want to compute an average of scores.” After the groups engaged in discussion for several minutes, Fuller asked each group to have one person report back to the class. After each student’s assessment of pH trends, she assessed the presentation as reporting a “fact” or a “general statement.” Fuller encouraged students to go beyond individual facts or data points to see patterns and trends in the data. The students’ statements ranged from detail statements such as, “The pH went up and down,” to more interpretive statements such as, “We think pH was acidic because of the pollution.” Next Fuller asked the students to search for relations among the three elements: pH, rainfall amount, and temperature. There was much discussion about hotter temperatures corresponding with increased rainfall. There was some discussion of how pH related to temperature or rainfall amount. In the final discussion, each group reported, and Gail directly questioned each group’s conclusions. Students decided that pH did not relate to rainfall amount, but that rainfall and temperature did appear to vary.

The impact of such activities on student learning and attitudes about science is positive, these teachers say. Student interest in environmental science is higher, said Linda Lenar at Harbor Beach. One student switched from accounting to environmental science. Another student said, “It’s helped me look at the environment more.” Lenar said the experience makes science “more real” for students.

The experience of engaging in critiques of findings and discussion of trends, as Fuller did with her students, goes to the heart of scientific practice. Teacher Sue Robinson of Phoenix plans to foster such discussion more in the future. She was surprised to learn through her GLOBE professional development activities that real scientists work in groups and engage in such discussions all the time. A recent GLOBE training program introduced her to scientists’ processes for debating and discussing their peers’ ideas.

> *I always thought they worked alone and then they published their results and here’s how they did it. And they said “No, you know, you work through these steps and then you get together with your colleagues and you present your paper and everybody tears it apart and says, ‘You could have done this better. Go back and do this one again.’ Or, ‘This is really great. And you all get together.” That’s how you do a project.*

A critical component of these teachers' focus was on scaffolding students' related linguistic and conceptual skills while collecting data. The teachers focused on the importance of using the proper vocabulary, evaluating findings in a general way, of being accurate, and of generating different explanations for their findings. These practices varied widely among our innovative teachers in terms of complexity and sophistication, suggesting that there are opportunities for GLOBE training to do even more to help teachers focus on advanced conceptual practices used by scientists.

Discussion

The findings from the case studies of the five innovative GLOBE schools provide an overview of some of the possible contributing factors to the highest and best use of the program. These factors are both organizational and individual. To summarize, it appears that support from the local administrator is a key organizational factor. There appears to be a need to expand the administrator's role to incorporate some of the responsibilities for outreach to other teachers at the school site. Second, with respect to individual factors, teachers who engage in innovative uses of GLOBE tend to be interested in investigating local environmental issues, strong leaders among their peers, and creative classroom managers. GLOBE would do well to bolster advanced GLOBE teachers' understandings of the more conceptual and critical aspects of scientific inquiry, such as data analysis and hypothesis generation. Their continued professional growth, if fostered by the program, is likely to do much to sustain their interest in GLOBE and their ability to support the participation of their colleagues.

Chapter 6. GLOBE International Partners

This chapter provides a brief description of recent activities of GLOBE international partners. This material serves as an update of the more extended discussion of international partner issues and activities in Chapter 7 of the Year 4 GLOBE evaluation report (Means et al., 1999).

Internationally, GLOBE is managed as a cooperative science and education program. GLOBE Partner countries have significant flexibility in deciding how to implement the program within the framework of the bilateral agreements or memoranda of understanding regarding standardization of GLOBE protocols, equipment, and training requirements.

This chapter highlights some of the strategies and collaborations being undertaken by international partners. The information in this chapter was obtained from interviews with Country Coordinators attending the GLOBE annual meeting and a review of resources available through the World Wide Web.

Scope of Participation

GLOBE participation internationally continues to rise. As of September 2000, 93 countries had signed bilateral agreements or memoranda of understanding defining partnership in GLOBE. By way of comparison, 21 countries had signed partnership agreements at the time the evaluation began (i.e., spring of 1995).

Many of the GLOBE measurement protocols and data-reporting forms are available in the six United Nations languages. As of our last report, 12 countries speaking languages beyond these six had translated GLOBE materials into their own language. Since that time, Estonia, Poland, Latvia, and Hungary all have either already translated materials or have plans to do so this year. Many partners (about one-third of GLOBE Partners) such as the Netherlands, the United Kingdom, the former Yugoslav Republic of Macedonia, Croatia, and Estonia host their own GLOBE Web site with translations or adaptations specific to the GLOBE Program in their countries (see Exhibit 6.1).

International Partner Strategies

The Year 5 survey of international partner Country Coordinators indicated that they see obtaining funding for the program as their biggest challenge. Other challenges Country Coordinators cited include obtaining political and institutional support, providing support to teachers who have been trained, and aligning GLOBE with national curriculum and assessment mandates. Below, we describe some of the strategies GLOBE international partners are using to address these challenges.

Exhibit 6.1 GLOBE Latvia Home Page

Obtaining Funding

Partnerships with corporations are increasingly important in making the GLOBE Program sustainable in many countries. In China, partnerships with commercial corporations and grants from their related foundations, such as Coca Cola, Ameritech, and Mobil Oil, have provided funding for the program staff, teacher training, equipment, and connectivity needed to implement GLOBE. In the Netherlands, Shell Oil and local Internet service providers are furnishing more funding for continuation of the program as government funding is being reduced.

In developing countries, organizations such as USAID, the World Bank, the Peace Corps, the British Council, KIDSGLOBE, and others are continuing to support the expansion of GLOBE in countries where internal resources for the program are scarce.

Obtaining Institutional and Political Support

Beyond the typical Ministry of Education or Ministry of Environment sponsorship, innovative public and private partnerships are often formed to assist with implementation of GLOBE in the areas of technology and telecommunications, equipment, and public relations. The program in Croatia provides an example of innovative partnering. In Zagreb, Croatia, the company that provides local waste disposal and environmental protection services, ZGO, and the City of Zagreb itself have provided funding for many of the local schools to implement GLOBE.

Programs in Norway and Iceland have found that forming links to the local community in the form of taking and reporting measurements that are necessary to monitor local conditions that affect the safety and quality of life in the community creates an important purpose for the program. In such cases, communities have been willing to support GLOBE in return for this important information. In Iceland, students were hired for the summer by the local town government to continue taking Hydrology measurements to see if they could help predict volcanic activity. Land Cover measurements are also being taken to help gauge environmental changes in the local area. In the Netherlands, partnerships with local communities are considered vital in generating public support for the GLOBE Program by linking data to environmental sustainability issues and giving these communities a sense of "ownership" of GLOBE.

In Estonia, GLOBE works in close cooperation with the Tiger Leap program, a state program for the employment of technology to benefit education. In a recent campaign to promote the Internet to the general public, GLOBE students gave presentations and demonstrated their use of the Internet in a tour of several towns.

Supporting Teachers

A number of international partners that have been active in the program for more than 2 years are now concentrating their resources on supporting and giving additional training to existing GLOBE teachers in an effort to prevent drop-offs in school participation. These countries are concerned that the number of teachers trained is much higher than the number actually implementing the program, especially in a sustained manner. Training resources in Norway, Estonia, Hungary, Spain, and Poland are focused on providing refresher training and training in more advanced protocols for current GLOBE teachers before training new teachers.

In addition to concentrating resources on the support of existing teachers, some of the partners are revising their criteria for recruitment of new schools and requiring more of a commitment from administrators. Croatia, for example, now requires teachers who take GLOBE training to return to their schools and present a synopsis of the program to their peers and administrators and to obtain a commitment from the school to the program before an ID number is assigned for data reporting.

The importance of the involvement of the schools' administration is also recognized by Poland, where a training was held in February 2000 specifically for school administrators from schools newly joining the program in an effort to lay the groundwork for administrative support for their teachers. A subsequent training session including administrators was held in September 2000. Poland has also created an Advisory Board that provides support to teachers. In Norway, providing teachers with the instrument kits has been effective in getting the schools to start participating quickly. Out of 10 new GLOBE schools that were provided with instrument kits recently, 8 have reported data so far.

Recognition for teachers, in the form of certificate programs and locating funding sources to provide extra pay, are support strategies under consideration in a few countries. Earning a citation on the GLOBE Chief Scientist's Honor Roll is also used as a criterion for allocating monetary incentives to schools in some countries. Spain gives teachers credit for filing an annual report on the status of the program at their schools.

In the United Kingdom, the GLOBE Program recognized the "slow take-up" of using GLOBE in the classroom by trained teachers and offered extended implementation support to any teacher who asked for it. The U.K. program soon saw an increase in the number of schools reporting data. Iceland is considering taking GLOBE training to individual schools and training as many teachers as possible at the school site rather than requiring teachers to go to a different training site.

Aligning GLOBE with National Curricula and Goals

Most GLOBE partner countries are trying to provide guidance to their teachers on aligning GLOBE with their own national curriculum. This issue continues to be one of the biggest challenges for program implementation—a challenge that teachers in the United States also face, albeit with state and district rather than national standards. GLOBE in the United Kingdom has cross-indexed portions of GLOBE to their national curriculum and adapted the Teacher's Guide to suit primary school implementation with adaptations for secondary school in the works. The Teacher's Guide for each investigation area cites the curriculum goals met by the GLOBE protocols. Pupil guides are also included at primary and secondary levels for each investigation area. These resources are downloadable from the U.K. GLOBE Web site.

Country Coordinators are also seeing changes in their countries' national curricula that are making the incorporation of GLOBE easier to accomplish. The science curriculum in the Netherlands, for example, recently changed and is now more closely linked to GLOBE activities. GLOBE Netherlands staff expect that it will take time for these changes to be implemented by teachers, however, because teachers must still figure out how to integrate GLOBE into their teaching. Iceland's curriculum was revised in 1999, and the changes are being phased in over a 3-year period. This year in China, the national curriculum has been changed from one that focuses on preparing students to pass a required examination to one that is much more standards-based. The daily schedule has also been somewhat freed in that a discretionary time period is provided in the school day when environmental science and other elective programs can be covered during class time rather than during non-school hours. In Japan, curriculum changes were expected to be instituted in 2000 which would allow more time for GLOBE activities. The Country Coordinator in Estonia has enlisted the assistance of a graduate student to help map GLOBE to the national curriculum.

The Growing Significance of International Collaborative Projects

GLOBE countries are finding that the program can be enriched and elaborated through international collaborations and special events. The collaborations below exemplify the partner countries' creativity and initiative in developing such collaborations.

Among countries with all or portions of their environments within the Arctic Circle, interesting collaborations are arising in areas such as phenology and food chain analysis. Iceland's Country Coordinator plans to work with CAFF (Conservation of Arctic Flora and Fauna,—a program of the Arctic Council whose members are Canada, Denmark, Finland, Iceland, Norway, the Russian Federation, Sweden, and the United States) and The Nature Research Institute to help monitor environmental changes through collecting information about phenology, the arrivals of migratory birds, and the awakening of insects in the spring. In Norway, a proposal Persistent Organic Pollutants (POPS) has been submitted by the Norwegian Institute for Air Research to the Norwegian National

Committee on Polar Research to study levels of toxic pollutants in the Arctic food chain (part of the Arctic Monitoring and Assessment Programme, an international effort including eight Arctic rim countries). Hydrology data from GLOBE students could be important in helping to identify sources of these pollutants in the relatively short chain and the proposal calls for a special GLOBE protocol to be developed for Arctic schools to take samples and find traces of specific toxic compounds. This proposal could help create a network of Arctic schools in several countries.

Peter Hardy, an Australian exchange teacher, solicited funding from commercial partners, and has successfully traversed much of the Arctic region of Canada while training teachers in GLOBE protocols and getting schools connected to the Internet along the way.

Near the Earth's other pole, GLOBE Argentina hosts a school for children of Argentine research staff located at an Antarctic research station where students are taking GLOBE measurements and learning about their local environment.

The phenology protocols developed by GLOBE Science Principal Investigator Dr. Elena Sparrow and her team from the University of Alaska, Fairbanks, are tools to help students understand seasonal phenomena and to see the effects of variations in temperature such as El Niño, La Niña, and global warming on their environment. Budburst was also measured by Norwegian and Czech schools collaborating on a joint student project comparing ten flowering plants common to both environments. Students found that budburst occurs in the Czech Republic about one month before it does in Norway.

Establishing ties of common goals between students in the program and their community helps develop a highly visible, sustainable relationship in which all stakeholders benefit—at both local and global levels.

Exhibit 6.2 GLOBE Stars Argentina

Escuela Provincial No. 38 Julio Argentina Roca, an Argentine-hosted GLOBE School in Antarctica, Esperanza, Argentina

Working on fields of ice and snow under the watchful eye of a flock of penguins, students in Antarctica are working hard to keep scientists updated on environmental conditions near the South Pole. A dozen students, whose Argentine parents work at a science observation site at the southern tip of the planet, attend the "Escuela N38" performing GLOBE protocols under the guidance of teacher Luis Alberto Brusasca.

"The students enjoy GLOBE very much because they can analyze real data to verify what they read about in the classroom," said Mr. Brusasca. "It enables us to know and understand the climatic conditions here. And it's one subject we can study outdoors, except when the winds get very high -- they can reach 110 knots!."

year old Paola, "especially when we walk several kilometers on the ice pack to reach the an unfrozen area of the sea and take water samples."

"I love GLOBE work because when we do it, I feel like a scientist," said 12 year old Paula, who hopes to be a biologist some day.

"This is a magic place," said 12 year old Cecilia. "To watch the ways of the penguins and other birds here is to really discover a different world; the great noise of icebergs breaking off, the blend of strange colors at sunrise. This place contains big questions that I can answer in part by myself with my own studies."

Regional Collaboration

Croatia hosted the First International GLOBE Land Cover Symposium in October of 1999. Teachers, students, and scientists from five countries (Spain, Iceland, Hungary, Croatia, and the United States) focused on remote sensing and practiced Land Cover/Biology protocols. Students also had opportunities to present their work.

Exhibit 6.3 Croatia Land Cover Symposium

A highlight of the Symposium was the field trip aboard the famous Pomorska skola boat, the first school boat with GLOBE flag. During the boat ride, participants made hydrology measurements comparing the samples taken in the harbor of Split and at the open sea. (The difference was found just in transparency and salinity of the samples. The sea water in harbor was less transparent and had smaller amount of salt).

Finally, in the Mediterranean woods near the historic city of Trogir, participants practiced the GLOBE land cover protocols with guidance provided by the scientists. "The symposium in Split surpassed my expectations," exclaimed Croatian GLOBE Teacher Marijana Pesic. "The GLOBE Program keeps giving us an opportunity to use modern teaching methods."

During the event, participants were welcomed by the Croatian Minister of Education and Sports, Mrs. Nansy Ivanisevicm and the mayor of Split. The International GLOBE Symposium on Remote Sensing /Land cover was organized by the Croatian Ministry of Education and Sports, the Office for Education and Sports of the City of Zagreb, and the waste management and environmental protection company ZGO.

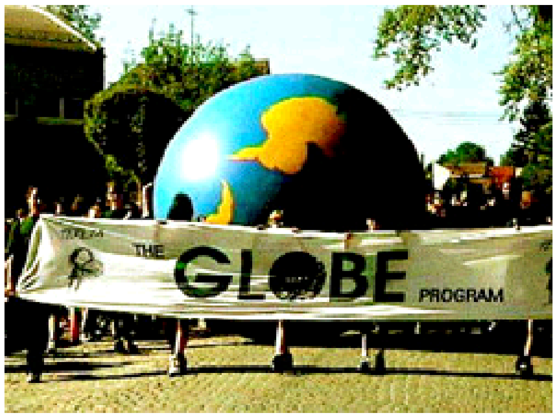
The Czech Republic held its third annual GLOBE Games where Czech, Norwegian, and Estonian students had opportunities to present and share their work. Students participated in a GLOBE-a-thon, including Land Cover/Biology, GPS, Soil, and Hydrology measurements as well as learning about the local history.

GLOBE Australia, in partnership with environmental education programs Airwatch, Commonwealth Scientific and Industrial Research Organisation (CSRIO) Division of Atmospheric Research, and Environment Australia, ran a special project on air quality that involved schools in Australia, China, and Pakistan. World Environment Day took place in June 2000, and students took GLOBE measurements as well as Airwatch program windspeed and direction measurements for a two-week period and reported them to the GLOBE Australia Web site. Students' findings and photos are posted on the site. Students compared their results and discussed them with CSIRO experts during a Web chat that took place June 5. Additional Web chats were held about the Air Quality Investigation and Hydrology.

Exhibit 6.4 GLOBE Stars Czech Republic

Czech GLOBE Games

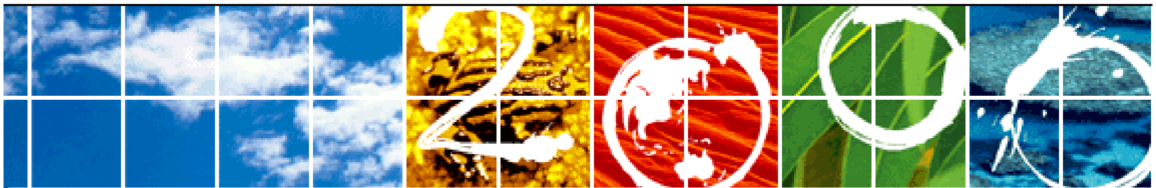
The Czech GLOBE Program celebrated Earth Day 2000 with their third Czech GLOBE Games recently, in Humpolec, Czech Republic. Almost 300 Czech students and 46 teachers from 33 schools, as well as Norwegian GLOBE Country Coordinator Karl Hetland with 36 students and 18 teachers from his GLOBE schools participated in the Games.



The opening ceremony took place on Saturday morning in Humpolec's town center where GLOBE students rolled a three meter globe through the streets. GLOBE Coordinator Dana Votapkova said, "it was moving to see so many students coming together to celebrate the environment and quite a sight to see them pushing a huge globe through the streets!" Town Mayor Jan Koten, Ministry of the Education representative Jana Cepelova, Norway's national GLOBE Coordinator Karl Hetland, and Czech GLOBE Coordinators Jana Ledvinova and Dana Votapkova opened the Czech GLOBE Games.

The actual science activities took place near the forest and ruins of the Orlik castle where student teams competed in recognizing tree types, measuring water quality and identifying clouds, as well as taking phenology measurements and studying remote sensing, soil and GPS. The students and teachers also participated in a GLOBE-A-Thon that focused on hydrology, soil and MUC protocols. Some students worked as journalists during the Games and prepared a special issue of the Czech GLOBE Newsletter while other students cheered the teams on and investigated the history, architecture and culture of the town.

Exhibit 6.5 World Environment Day Australia



WORLD ENVIRONMENT DAY Australia 5 June 2000

Student Air Quality Investigation

- Investigation
- Participating Schools
- Participating Organisations and Scientists
- Findings and Final Report
- Resources

Several Web Chats will be held to celebrate World Environment Day 2000.

The restricted Air Quality Investigation Web Chat will be held on Monday 5 June. The web chat times are as follows:

- 1 - 3 UT
- 11am - 1.00pm (ACT, NSW, QLD, TAS, VIC)
- 10.30am - 12.30pm (SA, NT)
- 9.00am - 11.00am (WA)

A Hydrology Web Chat will be held on Tuesday 6 June and is open to all GLOBE schools. Chat times are:

- 1 - 3 UT
- 11am - 1.00pm (ACT, NSW, QLD, TAS, VIC)
- 10.30am - 12.30pm (SA, NT)
- 9.00am - 11.00am (WA)

On Sunday 4 June, environmental experts from UNEP and the USA will be available to chat to students.
Full details on all web chats are available below.

- Web Chats

Regional collaboration in the form of educational symposia for coordinators and scientists is also important. The recent Air Quality and Education symposium in Santorini, Greece, provided an opportunity for the European GLOBE community to discuss strategies for integrating Air Quality education into their curricula and an opportunity to learn new GLOBE Atmosphere protocols.

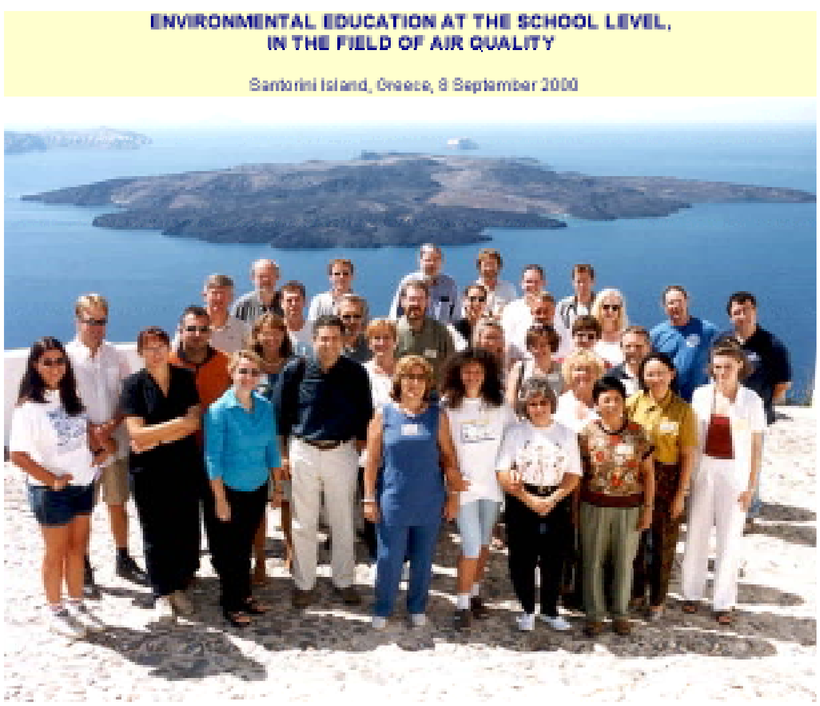
Exhibit 6.6 Air Quality and Education

Europeans Meet on Air Quality and Education

Belief that information gained through environmental education can assist in examining air quality brought GLOBE representatives from two dozen European counties to a symposium in Greece this fall. That meeting is expected to lead to further multi-national efforts

The workshop was organized by the University of Athens and the University of Helsinki and hosted by Greece. Costas Cartalis, Assistant Professor at the University of Athens, said "the workshop was organized in the framework of a research project funded by DG environment of the European Union. The workshop aimed at examining how air quality can be introduced in environmental education at the school level. GLOBE-Europe coordinators were invited to participate as experts in the field of environmental education at the school level."

"Everyone connected to GLOBE and to environmental education in general must appreciate what Costas fostered in this workshop," said Lyn Wigbels, GLOBE Assistant Director for International Programs. "Plans have been made here that will lead to further cooperation and coordinated work among the European GLOBE nations. That will benefit students and societies."



School-to-School Activities

Norway, the Czech Republic, Croatia, and Estonia continue to demonstrate the potential for international collaborative efforts with student projects, joint conferences, and workshops. Schools in the Netherlands are "twinned" (paired) with schools in Ecuador for student collaborations. Students in the Netherlands also are working with students in Germany on a study of the Rhine river. The Norway/Estonia school collaboration, initiated by Karl Hetlund and Ülle Kikas, won an environmental grant from SAS and Coca Cola. In September 2000, a seminar was held for teachers and administrators of the 18 schools involved to plan further collaboration.

Students in Japan have tried to foster collaborations with international schools but have experienced language barriers. Future collaborations may succeed if English teachers assist GLOBE students with translation of communications.

Discussion

The most significant challenges that all countries in the GLOBE program face are the issues of sustainability, funding, adaptation to local needs, and curriculum fit. Strategies that are proving most effective are:

- Linking data collection to a local environmental concern and developing a partnership between GLOBE students and the community to meet a mutual need.
- Providing teachers with sustained support (i.e., fostering administrative support within the teacher's school, training teams of teachers, providing refresher training, and following up after training).
- Translating and/or adapting GLOBE materials to suit the unique needs of the country.
- Meeting funding challenges with creative partnerships that expand beyond the support of government and quasi-government ministries and environmental agencies to include corporate and private enterprise sponsors, and the local community.
- Providing guidance on how GLOBE fits within the national curriculum and providing support to help teachers meet changing curriculum guidelines.

The international community has been able to foster interesting regional and school-to-school collaborations in the form of joint projects and events where students, teachers, coordinators, and scientists from diverse countries learn together and form lasting relationships. Even in this age of online communities, face-to-face communication is still highly important in creating sustainable relationships—GLOBE partners are using Internet communication to supplement, but not supplant, face-to-face meetings with their teachers, sponsors, and international collaborators.

Chapter 7. Student Learning

GLOBE's goals include improving students' understanding of and achievement in science as well as increasing their awareness of the global environment from a scientific perspective. Year 5 evaluation activities addressed these learning issues in two ways, first by obtaining data on teachers' perceptions of what their students have learned through GLOBE and second through direct assessments of students' environmental awareness and ability to use climate data to make and defend conclusions.

Teachers' Perceptions of What Students Learn

Teachers who implemented GLOBE with students were asked in our survey to evaluate the extent to which their students had improved in various types of skills and content knowledge because of their GLOBE experience. As Table 7.1 shows, recently trained teachers who implemented GLOBE with their students in 1999-2000 reported improvement at the "very much" level for students' observation skills (62%), their measurement skills (50%), their ability to work in small groups (40%), their ability to understand data (39%), and their technology skills (26%). Teachers in our active sample were even more likely to report that student skills had improved "very much" as a result of GLOBE participation: 71% for observation skills, 74% for measurement skills, 53% for the ability to work in small groups, 46% for the ability to understand data, and 45% for technology skills.

When teacher responses are summed across the top two categories presented in Table 7.1, 98% of active teachers and 91% of recently trained teachers implementing GLOBE with students reported that their students' observation and measurement skills improved "very much" or "somewhat" because of their involvement with GLOBE. For each of the top four areas of student improvement, more than 90% of active teachers and more than 80% of trained teachers judged their students' skills to have increased "very much" or "somewhat." Approximately half or more of the teachers in both samples reported this level of improvement for each area except those related to language skills.

Although active teachers generally reported higher rates of improvement at the "very much" level for their students than trained teachers reported, active and trained teachers reported comparable rates of improvement at the "somewhat" level. One possible way to view this finding is in relation to levels of implementation. Recently trained teachers,

Table 7.1
Teacher Reports of How Much Their Students' Skills Increased with GLOBE[1]
(Percent Reporting)

Skill Area	***Very Much***		***Somewhat***		***Not Very Much***		***Not at All***	
Sample	Trained	Active	Trained	Active	Trained	Active	Trained	Active
Observation skills	62	71	29	27	<1	1	3	<1
Measurement skills	50	74	38	24	3	<1	4	<1
Ability to work in small groups	40	53	42	40	6	5	5	1
Ability to understand data	39	46	43	45	6	5	6	3
Technology skills	26	45	37	39	13	10	13	2
Critical-thinking skills	31	31	43	47	10	14	7	4
Map skills	17	16	31	40	19	22	18	15
Ability to regulate own learning	14	19	40	43	19	20	14	9
English language skills	9	11	28	32	23	26	26	22
Other language skills	6	4	19	13	16	17	39	52

Sample sizes: Trained = 247 ≤ n ≤ 262, Active = 445 ≤ n ≤ 470

who generally implement GLOBE for less time and with less experience than active teachers, report moderate rates of improvement in student learning at levels similar to active teachers, but are less likely to see strong effects. On the other hand, it is equally reasonable to suggest that those teachers who perceive great GLOBE-related improvements among their students are motivated to devote more time to the program (and hence are more likely to qualify for the active school sample).

Table 7.2 shows teacher ratings of the magnitude of GLOBE's impact on eight content areas, including the six GLOBE investigation areas and two additional areas, geography and "earth as a system." Seventy-nine percent of active teachers and 56% of recently trained teachers reported that student knowledge about Atmosphere had improved "very much." "Earth as a System" was the next most highly rated area (27% trained; 32% active), followed by Hydrology (27% trained; 29% active).

[1] In the survey items on which this and the following table are based, teachers were given the four-point scale presented in these tables and an additional response option, "Don't Know." Teacher data for this last option are not reported here.

Table 7.2
Teacher Reports of How Much Student Content Knowledge Increased (Percent Reporting)

Knowledge Area	***Very Much***		***Somewhat***		***Not Very Much***		***Not at All***	
Sample	Trained	Active	Trained	Active	Trained	Active	Trained	Active
Atmosphere	56	79	29	19	3	<1	6	<1
Hydrology	27	29	25	27	6	10	31	28
Land Cover/Biology	12	13	18	23	15	18	40	38
Soil	16	14	21	18	14	15	36	46
Earth as a System	27	32	34	39	9	10	18	13
Seasonal Cycles	16	19	24	30	14	14	30	29
GPS	21	21	24	30	14	15	29	29
Geography	13	17	32	41	13	16	27	20

Sample sizes: Trained = $246 \le n \le 263$, Active = $431 \le n \le 471$

The amount that students learn in a given GLOBE content area is, of course, a function of the extent to which activities relevant to that content area were implemented. To better understand the perceived power of GLOBE activities to enhance content knowledge, an analysis was conducted in which teacher evaluations of student knowledge gains are reported only for those teachers who had implemented activities in the related investigation area with their students. This analysis removes the factor of differential implementation rates in examining student knowledge gains. When analyzed in this manner, as Table 7.3 shows, the wide differences between knowledge increases in the various investigation areas are reduced, giving an indication that when GLOBE investigations are implemented, there is broad teacher consensus that students gain knowledge in the relevant content area. The highest rates of knowledge gains are still in the Atmosphere area (63% for trained and 79% for active at the "very much" level), but knowledge gains in the other content areas are rated much more highly than without the adjustment for implementation. Additionally, the rates of knowledge gain for the non-Atmosphere investigation areas are more comparable to one another.

Table 7.3
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***	
Sample	Trained	Active	Trained	Active	Trained	Active	Trained	Active
Atmosphere	63	79	30	19	3	<1	3	<1
Hydrology	50	48	35	41	5	6	5	4
Land Cover/Biology	32	30	40	46	14	17	7	4
Soil	37	42	41	36	16	13	2	6
Seasonal Cycles	46	42	38	44	14	10	2	2
GPS	48	47	33	44	13	7	3	3

Sample sizes: Trained = $246 \le n \le 263$, Active = $431 \le n \le 471$

Interestingly, with the adjustment for rates of implementation, the relationship between knowledge gains reported by trained and active teachers shifts somewhat. Trained teachers are just as likely as active teachers to report that student knowledge increased “very much” in most content areas (Hydrology, GPS, Seasonal Cycles, and Land Cover/Biology). Rates for knowledge gains reported by trained and active teachers are much more similar than when implementation rates are not taken into account. Adjusted for the level of implementation, 91% percent of both trained and active teachers reported knowledge gains for the GPS area, for example, whereas trained teachers reported a rate of 42% and active teachers a rate of 54% when left unadjusted.

Student Learning Assessments

In addition to teachers’ perceptions of student learning, we sought direct evidence of GLOBE students’ understanding and ability to work with environmental data. To obtain such evidence, we developed Web-based assessments for the evaluation. The results from a pilot study using online assessments of environmental awareness and problem solving with environmental data in Year 4 suggested that GLOBE contributes to students’ awareness of environmental concepts and data analysis skills. In Year 5, we sought a more definitive test of this idea by comparing performances of groups of high school students who had participated in GLOBE to varying degrees. Students were drawn from GLOBE classrooms that report large amounts of data and from GLOBE classrooms that report an average amount of data. We also assessed a comparison group from classes not involved with GLOBE. Students took the GLOBE assessments online, working in small groups of two to four students. In total, 93 student groups were included in the data analysis.

The online assessment tasks (see Year 4 evaluation report) were designed using criteria drawn from cognitive research (Blum & Arter, 1996; Darling-Hammond, Ancess, & Falk, 1995; Perrone, 1991). The environmental awareness assessment tested students' skill in framing observations of the environment using the language of science. The second assessment task required students to interpret data and then write up their conclusions and present evidence in graph form. Essentially, this task required students to develop an argument to demonstrate their skill in reasoning using data. Developing such evidence-based explanations is an important part of teaching students to think as scientists (Chi, deLeeuw, Chiu, & LaVancher, 1994; Coleman, 1998; Coleman, Brown & Rivkin, 1997; Ohlsson, 1992; O'Malley, 1987; Webb, 1989).

An online environment was selected for the assessment for several reasons. First, it allowed students to engage in realistic complex tasks and to use the type of automated graphing tools used by scientists (Pea, 1994). Online administration also had the advantage of allowing us to collect data from a broader geographic region than would have been feasible if researchers had to be present for the administration.

Sample and Recruitment

The two samples of GLOBE classrooms—high reporters and average reporters—were selected by examining data reports on the GLOBE Web site. The high-reporting schools were a random selection from those schools that had submitted data reports with a frequency at least one standard deviation above the mean number of data reports for all GLOBE schools during the fall of 1999. The average reporters were selected at random from those schools that had made close to the mean number of data reports to the Student Data Archive during that same time period. The comparison group was comprised of a random selection from high schools with teachers who had signed up for GLOBE training, but had not yet completed the training or started the program.

Schools were invited to participate in the student assessment. During recruitment, we screened participants to make sure they had sufficient time and technological capacity to administer the online assessments. Although the assessments took only one hour for students to complete, some schools lacked a sufficient number of computers to administer the assessment in a timely manner. Others faced time constraints caused by spring vacations and standardized testing. All participating classrooms had Internet access, Netscape 3.0 or higher, and computers with a 256-color monitor display and 16 MB of RAM.

Our participating sample was comprised of 9 high-reporting schools, 9 average-reporting schools, and 14 comparison schools. These schools were dispersed across the continental United States. Students in eighth- through twelfth-grade participated. They came from science classes of all types and all difficulty levels. For our analyses, we used data only from classrooms that completed the online assessments. Our final sample included 93 student groups: 31 high-reporting, 31 average-reporting, and 31 comparison groups from the classrooms in the sample.[2]

In addition to the online assessments, we also administered pre- and post-surveys to collect information about the size, grade level, and type of classes participating in our assessment. These surveys also provided insights into the teachers' views of the students' knowledge and skills in the area of environmental science, their classroom activities related to data analysis and use of technology, and their students' experiences with the online assessments. Table 7.4 shows the kinds of activities that teachers of the high- and average-reporting classes said their students engaged in as part of GLOBE. Activities in the two sets of classes are generally similar in kind, with the exception of telecommunicating with other GLOBE schools (which was much more common among high implementers).

Description of Assessment Tasks and Findings

In this segment, we describe the online assessment segments and their findings separately. First, we discuss the environmental awareness task, and then the data analysis task.

[2] Because we had data for an uneven number of student groups across samples, we randomly selected groups from among average-reporting and comparison groups (of which there were more) to create three samples with equal numbers of student groups for statistical analysis. This is a common procedure used by researchers performing statistical analysis when sample sizes are not equal.

Table 7.4
Comparison of GLOBE Activities in High- and Average-Reporting GLOBE Classrooms

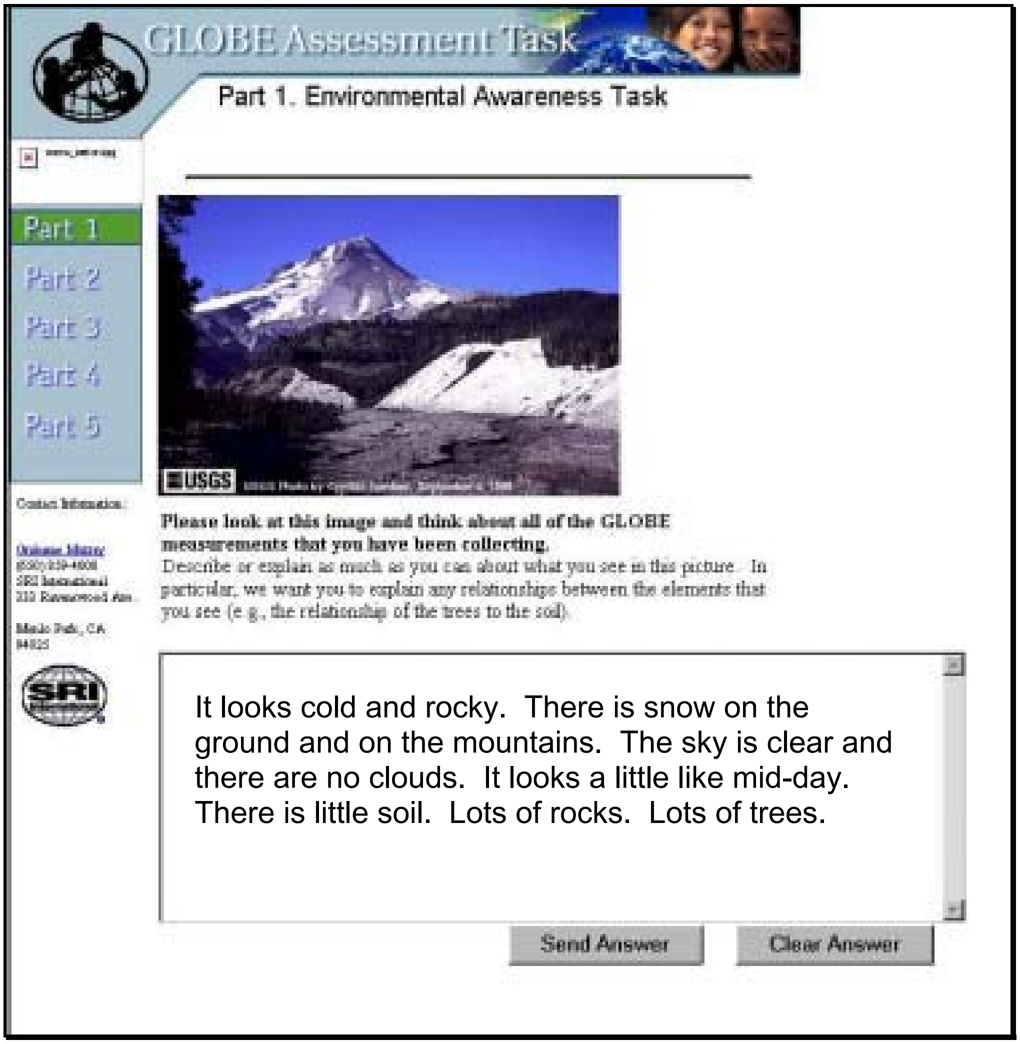
Classroom Activity	***Average Implementers N=7***	***High Implementers N=7***
Take GLOBE measurements	6 (86%)	7 (100%)
Enter GLOBE data into computer	6 (86%)	7 (100%)
Explore GLOBE Web site	5 (71%)	6 (86%)
Analyze, discuss, interpret data	5 (83%)	6 (86%)
Telecommunicate with other GLOBE schools	1 (17%)	5 (71%)
GLOBE-based student investigations	4 (67%)	6 (86%)
Collaborations with other GLOBE schools	1 (17%)	1 (17%)
Engage in GLOBE learning activities	6 (86%)	6 (86%)

The Environmental Awareness Task

Promoting environmental awareness is a key goal of GLOBE. Environmental awareness is defined as a scientifically informed perception of the environment as a coherent set of interdependent elements. Over the last several years, we have developed a technique for eliciting students' environmental perceptions by interviewing students as they observe an image of a natural scene (see Year 3 and Year 4 evaluation reports). We have found that more knowledgeable students demonstrate awareness of the interconnected and underlying dynamic quality of the different natural elements in the picture, whether interviewed in person by a researcher or assessed through a Web-based set of queries.

In the online assessment of environmental awareness, students viewed an image of Mt. Hood (see Exhibit 7.1) and were asked to write about what they observe. They viewed the image under two conditions. In the first condition, they were asked simply to think about the relationships among the different elements they observed in the picture. The second condition prompted them to think about how the water cycle works in the environment. The two conditions allowed us to see what observations and scientific concepts students generated on their own, without prompting, and what scientific concepts they generated when prompted to illustrate their understanding of a particular environmental concept. The online assessment featured two pages where students could enter their responses into form boxes while viewing the photograph of Mt. Hood (see Exhibit 7.1).

Exhibit 7.1



After the student responses were culled from the server and entered into Excel spreadsheets, we coded each student group's response to identify whether the groups made inferences about either environmental processes or water cycle concepts in the environment. Our analysis of performance in the unprompted condition distinguishes between descriptive statements and environmental inferences.

Descriptions are statements about features that are overtly visible in the scene. These statements lack any reference to key underlying ecological ideas or causal relationships. For instance, when asked to identify elements and relationships between elements found in the image, many students referred to basic ideas about object, color, shape, or similarity to other places. The student response in Exhibit 7.1 is a typical descriptive statement.

Inferences about Environmental Processes refer to phrases that reflect an inference of an underlying ecological theme or big idea within environmental science—such as interdependence or cycles (see Exhibit 7.2 for definitions). For example, students

Exhibit 7.2
Definition of "Big Ideas" of Environmental Science

- ***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.
- ***Cycles*** refer to the idea that all components of the environment 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 environment 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). The erosion cycle refers to how the soil is formed.
- ***Ecosystems*** refer to the idea that there is a distinct area that combines living (biotic) communities with nonliving (abiotic) environments, including 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 affect the composition of the water, air, and land).

might refer to an underlying process that created a relationship between the elements in the picture. Inferential phrases describe the dynamic processes that produced what the students saw. The following example illustrates an inferential student response:

> *"The river most likely provides water supply to the trees growing on its banks." (Inference: interdependence) The mountain's steep walls act as sliding boards for the falling rain to pass into the river. (Inference: cycles) By this happening, the water is weathering the mountain and causing small pieces to break off (Inference: cycles), forming sedimentary rocks (Inference: cycles). These rocks soon are affected by physical, chemical, and organic weathering (Inference: cycles). This then creates the soil in which the trees grow (Inference: cycles)."* (Student Group Response)

Water Cycle Inferences refer to phrases that contained an explicit mention of one of the phases of the water cycle (see Exhibit 7.3 for phases). For example, the student would use the scientific terms to describe one phase of the cycle or accurately describe the process. The following illustrates this:

> *"The water condenses (Inference: condensation), forms snow, the snow falls on top of the mountain (Inference: precipitation) and the sun melts the snow. The water runs down the mountain (Inference: surface runoff), adding to streams and is absorbed by the soil alongside the streams (Inference: Infiltration). The trees absorb the nutrients from the soil as well as the water. Without the water cycle, none of this is possible."* (Student Group Response)

Exhibit 7.3
Water Cycle Phases

- ***Evaporation*** is the process in which a liquid—in this case, water—changes from a liquid to a gas.
- ***Condensation*** occurs when a gas is changed into a liquid. Condensation occurs when the temperature of the vapor decreases.
- ***Precipitation*** occurs when the temperature, available moisture, and atmospheric pressure are right and small droplets of water or ice crystals in clouds grow larger and fall to the earth.
- ***Surface runoff*** is precipitation or melted snow and ice that flows across the surface of the land, downhill into streams, rivers, ponds, lakes, etc.

Exhibit 7.3
Water Cycle Phases (Concluded)

- ***Infiltration*** is the flow of precipitation or melted snow and ice into the ground.
- ***Transpiration*** is a process by which water vapor escapes through plant leaves. As plants absorb water from the soil, water moves from the roots through the stems to the leaves. Once the water reaches the leaves, some of it escapes from the leaves, adding to the amount of water vapor in the air.

Two members of the evaluation team coded the student responses. Each researcher coded a subset of responses independently to establish the reliability of the coding scheme. Inter-rater reliability was 85.2 % for the coding of inferences and 84.7 % for the identification of inferences about water cycle phases.

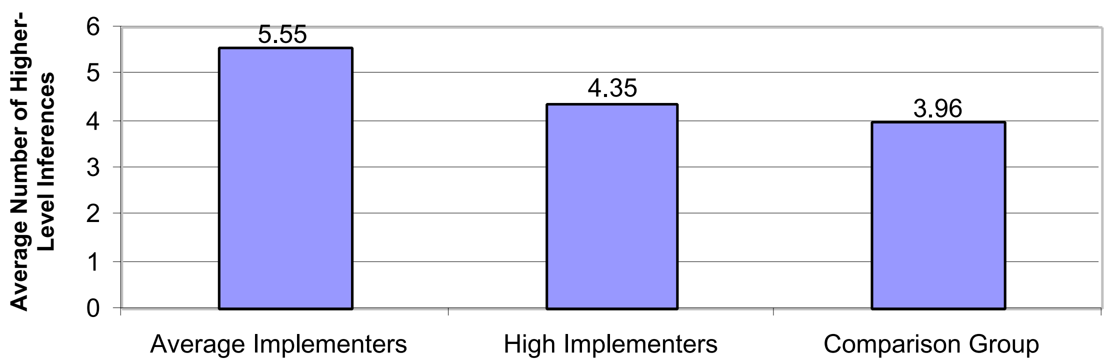
In coding the responses, we found that most students used descriptive language rather than scientific inferences in the unprompted condition. When they did make inferences, students tended to focus on cycles and interdependencies in the environment more than on adaptation, pollution, and ecosystems. They were more likely to refer to cycles and interdependencies in the prompted condition (Table 7.5).

Table 7.5
Percentage of All Responses (All Groups) Mentioning Environmental Concepts

	Unprompted Condition	***Prompted Condition***
Descriptions	53	19
Cycles	24	83
Interdependence	22	17
Adaptation	9	0
Pollution	9	0
Ecosystems	0	0

When we reviewed the results, we found two key differences among the three GLOBE groups. First, both the high and average GLOBE implementation groups made reference to more of the "big ideas" of environmental science than did the comparison group. These differences among groups were not quite statistically significant (F=2.92, p=.06), but strongly suggest an influence of GLOBE on students' environmental awareness (see Figure 7.1).

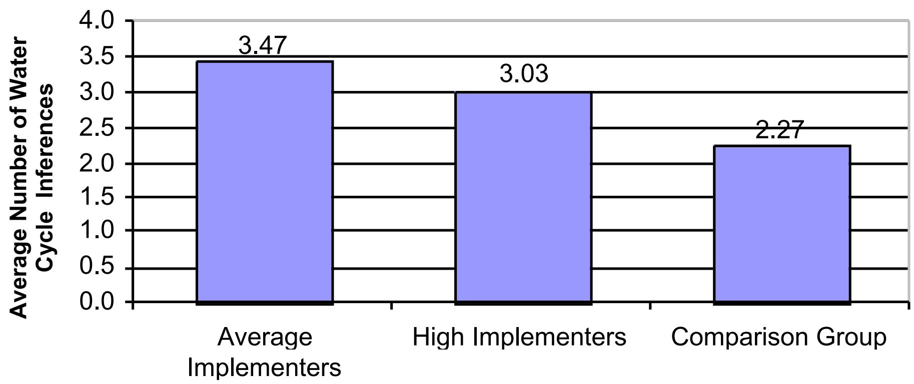
Figure 7.1
Environmental Awareness Task: Core Concepts of Environmental Science (Unprompted)



What's noteworthy here is that these differences are observed in the "unprompted" condition of the task. In other words, without any special prompts to talk about the image of the environment in scientific terms, GLOBE students were more likely than comparison students to spontaneously describe the patterns and relationships they saw using the language of environmental science concepts.

Students in the average- and high-reporting GLOBE groups also mentioned more phases of the water cycle than did the comparison group. Of the seven key phases of the water cycle, average- and high-reporting groups mentioned more than half of the concepts, while comparison group students mentioned about a third. These differences were statistically significant (F=5.23, p<.01), and suggest that GLOBE may have a positive influence on students' ability to perceive and describe specific aspects of an important cycle in the Earth system (see Figure 7.2). It is particularly noteworthy that this distinction occurred with a rather commonly taught scientific construct – the water cycle. This suggests that GLOBE fosters a richer understanding of how natural, scientific processes function in the environment.

Figure 7.2
Environmental Awareness Task: Water Cycle References (Prompted)



The Data Analysis (Olympic) Task

The second part of our online performance assessment measured students' skills in data analysis, decision making, and communication using environmental data. GLOBE teachers are encouraged to have students collect data about the environment, analyze it, interpret it, and communicate what they have learned from the data. Our online performance task assesses students' ability to analyze and interpret data within a motivating problem context. In the task, students are asked to determine a good site for the Winter Olympics using climate data.

In this Olympic task, we asked students to select from among five cities the best site for a future Winter Olympics, on the basis of climate-related criteria set by the Olympic Committee. The second part of the task requires students to prepare a presentation for the Olympic Committee, announcing their site recommendation and showing the data that led them to this choice. Exhibit 7.4 shows the guidelines we provided to students to help them make their decision.

To solve the problem, students navigated through a series of Web pages containing climate data and data about the elevation and latitude of five cities with the goal of selecting the ideal site for the next Winter Olympics (see Exhibit 7.5).

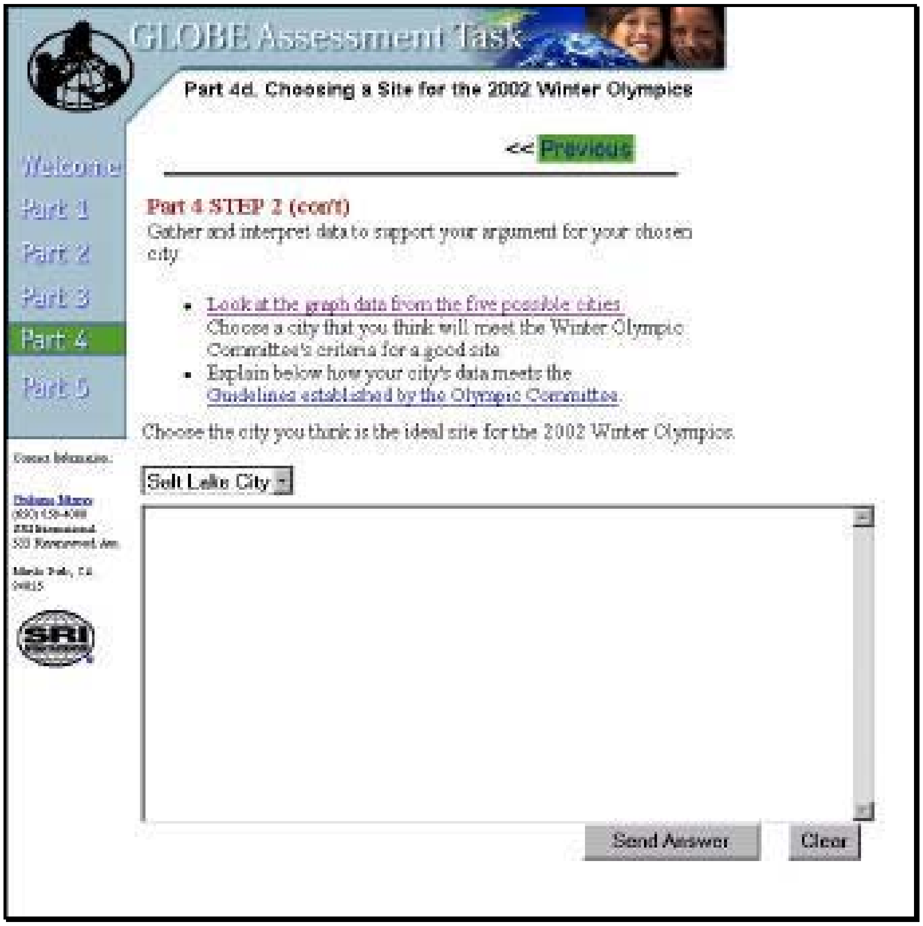
Exhibit 7.4
Olympic Task Decision Guidelines

- The mountains need to be at least 1000 meters tall, as measured from the base of the mountain.
- There needs to be at least 1000 mm of snow from December to February, so that there will be enough snow on the ground in February, when the Olympics will be held.
- The base camp should be warm and sunny, so that people can enjoy watching from outside.
- The mountain peaks should be cold enough so that the falling snow doesn't begin to melt and turn to ice.
- Latitudes closer to the equator are preferred as long as there's enough snow.

In the course of working on this problem, students were asked to produce at least two graphs that compared the city they thought would be the best Olympic site with another city. Students were also asked to explain why the graph supported their argument. The graphs and reasons constitute the *backing* (Toulmin, 1958) to students' arguments and represent their attempts to ground their problem solving in the data and guidelines provided.

The results of the Olympic task showed a wide range in quality. In scoring student performance on this complex task, we analyzed three key aspects of the task: amount of evidence collected, city choice, and the quality of the generated graphs (i.e., whether the variables most supportive of the students' choice were graphed for the presentation). One city did in fact meet all the Olympic Committee criteria and surpass all competitors on most of the climate dimensions. The resulting measures reflect students' ability to mine data to make a decision and to support an argument. The graph selection measures students' ability to critically assess sets of data and select the pieces most relevant for supporting a conclusion. The city choice reflects students' ability to draw a conclusion based on multiple criteria and corresponding data sets. Each of these measures represents different phases of the reasoning and data-driven inquiry process: data collection, critical selection and argumentation, and final conclusion.

Exhibit 7.5



Students who performed the best selected the city that met all of the Olympic Committee's criteria and cited the data and those criteria in their explanation of why they selected that particular city. For example:

> *"Flagstaff seems like the ideal place for the winter olympics to take place. There are about 11 days out of the month of February with sunshine. So the people wanting to watch at the base camp can watch outside with plenty of sunshine and warmth. The Peak elevation is 3506 ft* [sic] *and the requirements for the Olympic Committee is only 1000 ft* [sic]*. The Maximum temperature at the base for Flagstaff is 7° Celsius, and the requirements for the Olympic Committee is cold enough so that the snow doesn't fall, melt, then freeze into ice. The Maximum temperature at the peak is -2° Celsius that's not too cold for the competers. The olympic Committee says the closer to the equator the better as long as there's enough snow to meet the criteria. And it does. The average snow fall for Flagstaff is 1389 mm and it meets the*

> *requirements for O.C. by 389 mm. We think that Flagstaff is the best place to host the winter olympics."*

In this answer, the students responded to most of the criteria correctly: mountain height (though the units were incorrect), snow at least 1000 mm deep, location close to equator preferred, and sunny base camp. They attempted to respond to the other criteria as well: relatively warm temperatures at the base and relatively cold temperatures at the mountain peaks. In these latter cases, however, they got the rationale for these temperature preferences confused. The maximum temperature at the peak needed to be cold so the snow would not melt too quickly, and the base temperature needed to be relatively warm to ensure the comfort of the spectators. Overall, this is a strong response because it addresses each of the criteria systematically.

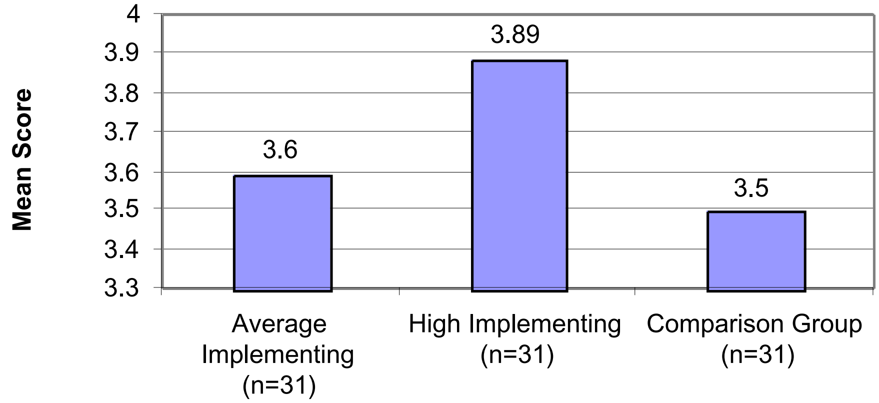
Other student groups turned in writing that missed some or most of the elements of a quality argument. Some groups selected a city that failed to meet one or more of the Olympic Committee criteria, some did not deal with the Olympic Committee's selection criteria in their explanations, or simply failed to explain their decision-making process thoroughly. Examples of these types of responses are:

> *"We looked at the statistical information from all of the sites and chose which one best met the requirements, but was not lacking too much in its lower areas. For example, Flagstaff best met all of the requirements except in maximum peak temperature. Their temperature was so low, that with the aid of sunlight, their snow could melt. Salt Lake City was just under Arizona in most categories, but it did not reach the rainfall requirements as stated in the guidelines. Innsbruck is not the top in all categories, but it nicely meets all the requirements and is not extremely lacking anywhere."*

> *"We compared the data given to us on the graphs. Elevation, temperature, and the sunny days were all considered when making the choice between the five cities. Although all of the choices would be ideal sites for the winter games only one of the sites can be used. After comparing the data Canada was chosen."*

When comparing the three GLOBE groups on this complex outcome measure, we found that high-reporting GLOBE classes achieved a mean score of 3.89 compared to average implementers, who scored 3.6, and the comparison group, which scored 3.5 (see Figure 7.3.

Figure 7.3
Olympic Task: Evidence of Student Reasoning



The differences among the three groups, although not statistically significant, reveal an encouraging trend, suggesting that more intensive implementations of GLOBE enhance students' ability to reason with environmental data.

Discussion

GLOBE teachers, especially teachers in the most active schools, perceive GLOBE as having positive effects both on student knowledge in environmental science content areas and on student skills in areas of observation, measurement, collaboration, data analysis, and technology.

This year's performance assessment provides empirical support for the hypothesis that GLOBE improves students' awareness of the interdependent elements of their environment. GLOBE students appear to develop a richer ability to discern and infer different aspects of a complex natural dynamic process, such as the water cycle, while observing the environment. GLOBE students who examined an image of an environmental scene were more likely than comparison students to make higher-level inferences about that scene that made references to cycles and interdependencies in natural systems and ecosystems, and were better able to articulate how the phases of the water cycle (evaporation, precipitation, surface runoff, etc.) would unfold there.

The online assessment results also provided us with some evidence that students who collect more data in GLOBE are more likely to do well in all phases of the data analysis process: collection, argumentation, and conclusion.

Chapter 8. Discussion

Nearly 15,000 teachers from almost 10,000 schools in 95 countries had participated in GLOBE by school year 1999-2000. The GLOBE partner model for scaling up through partnering with organizations to provide teacher training in the United States and memoranda of understanding creating sister programs outside this country has proved its feasibility. In this report, as the program is on the threshold of a new phase, with a new and greatly expanded Teacher's Guide planned for 2001, we seek to provide a multi-dimensional portrait of the program's status in school year 1999-2000 and its evolution since its beginnings in 1995.

A Record Year for Teacher Training

The number of teachers receiving GLOBE training reached a new high in 1999-2000. Within the United States. alone, 2,965 teachers were trained in GLOBE. Nearly all of these (93%) received their training from a GLOBE partner (rather than from trainers working under contract to the GLOBE Program office). Comparing data from GLOBE teachers who had been trained in 1998-99 versus those trained 2 years earlier, we found that the more recent cohort included a somewhat larger proportion of elementary teachers (in the United States) and were more likely to be the second or third, rather than the first, GLOBE teacher trained for their school.

Our "recently trained teacher" survey sample provides a portrait of the GLOBE involvement of teachers who received training between June 1998 and August 1999. Half of the teachers in this sample implemented GLOBE activities with students during the 1999-2000 school year. The half of the recently trained teachers who implemented GLOBE with students do not capture the full impact of the training, however. Some of those who did not use GLOBE with their students in 1999-2000 may well do so in future years. Moreover, nearly all of the recently trained teachers (97%) reported that the GLOBE training influenced their practice in some way. The most commonly cited influences— more emphasis on observation and measurement and more hands-on activities and data analysis—are in keeping with the science education teaching standards promoted by the National Research Council (NRC). Those standards include: creating an environment that is supportive of scientific inquiry; structuring available time so that students can engage in extended investigations; encouraging and modeling scientific inquiry skills, including openness to new ideas and data; providing scientific tools, materials and technology supports; identifying and using resources outside the school; and giving students a significant voice in decisions about the content and context of their work. The recent addendum to the science education standards, *Inquiry and the National Science Education Standards* (National Research Council, 2000), provides a more elaborate description of the essential features of inquiry-oriented science instruction, as shown in Figure 8.1. As the figure shows, the essential features of inquiry can be implemented with varying degrees of teacher guidance; because few students are initially ready to undertake scientific investigation without external supports, the NRC recommends experiences that vary in degree of guidance in order to develop student abilities. GLOBE content and activities offer a rich set of resources for providing experiences in scientific inquiry with varying degrees of support (e.g., ranging from following preset protocols for data collection to figuring out what kind of data to collect to answer the student's own question).

Changes in Implementation Patterns

When survey responses of recently trained teachers implementing GLOBE in Year 5 were compared to those of recently trained teachers implementing the program in Year 3, we found some evidence of a shift in the components of the program emphasized by new teachers. Recently trained teachers in Year 5 were more likely than those in Year 3 to involve students in learning activities (75% for Year 5 compared with 63% for Year 3) and in analysis, discussion, and interpretation of GLOBE data (56% for Year 5 compared with 43% in Year 3). Recently trained teachers implementing GLOBE in Year 5 were less likely to report involving students in taking measurements (82% versus 96% for Year 3) and much less likely to involve students in entering GLOBE data on the computer (44% compared to 63% in Year 3). The reasons behind this apparent shift in emphasis among recently trained teachers will be a target for future evaluation activities. In response to a survey item asking for reasons that data which had been collected were not reported to the GLOBE database, teachers cited pragmatic considerations related to limited time and technology.

When we examined the specific GLOBE data collection protocols that recently trained GLOBE teachers were using with their students, we found evidence of another shift from earlier patterns. While Atmosphere protocols remain far and away the most commonly implemented, the proportion of recently trained teachers implementing them

Figure 8.1
Features of Classroom Inquiry and Variations in Their Implementation

Essential Feature	Implementation Variations			
Learner engages in scientifically oriented questions.	Learner poses a question.	Learner selects among questions, poses new questions.	Learner sharpens or clarifies question provided by teacher, materials, or other source.	Learner engages in question provided by teacher, materials, or other source.
*Learner gives priority to **evidence** in responding to questions.*	Learner determines what constitutes evidence and collects it.	Learner directed to collect certain data.	Learner given data and asked to analyze.	Learner given data and told how to analyze.
*Learner formulates **explanations** from evidence.*	Learner formulates explanation after summarizing evidence.	Learner guided in process of formulating explanations from evidence.	Learner given possible ways to use evidence to formulate explanation.	Learner provided with evidence.
Learner connects explanations to scientific knowledge.	Learner independently examines other resources and forms links to explanations.	Learner directed toward areas and sources of scientific knowledge.	Learner given possible connections.	
Learner communicates and justifies explanations.	Learner forms reasonable and logical argument to communicate explanations.	Learner coached in development of communication.	Learner provided guidelines to sharpen communication.	Learner given steps and procedures for communication.
	More ⇐ Amount of Learner Self-Direction ⇒ Less			
	Less ⇐ Amount of Direction from Teacher or Material ⇒ More			

Source: National Research Council. (2000). *Inquiry and the National Science Education Standards: A Guide for Teaching and Learning*. Washington, DC: National Academy Press.

has dropped somewhat, while the proportions of those teachers who are implementing protocols in the other three investigation areas have risen. The Hydrology and Soil investigations have seen the biggest increases in activity. Comparing those protocols that individual recently trained teachers reported implementing themselves with those they reported were implemented by someone at their school, we inferred that in many cases, recently trained GLOBE teachers are expanding the range of protocols implemented by their schools by "filling in the gaps" and implementing protocols and learning activities not being used by their colleagues. As the proportion of GLOBE schools with multiple teachers implementing GLOBE activities rises, it will be important to track GLOBE experiences at the student level because individual students may work on GLOBE with multiple teachers, either across years or within a single year.

Elements of Successful Adaptations to Local Circumstances

Our teacher survey provided several indications of the challenges teachers face when implementing GLOBE. First, teachers who were not implementing GLOBE with students in 1999-2000 were asked to report the reasons for their inactivity. Issues of time, scheduling, and curriculum mandates were the most commonly cited reasons for not using GLOBE. Fifty-two percent of the recently trained teachers not implementing GLOBE with students in 1999-2000 cited lack of time to prepare as a "major barrier." Open-ended survey items asked teachers who implemented GLOBE with students to indicate the reasons why they chose particular protocols and learning activities. The dominant reasons cited for choosing certain protocols—minimal time requirements and curriculum fit—suggest that teachers are less likely to use protocols and learning activities they perceive as lacking these qualities. Finally, we asked teachers who had ever had their students collect GLOBE measurements that they did not submit to the Student Data Archive to indicate the reasons for this omission. The most frequently cited issues were lack of time to do the data entry and low confidence in the quality of the data. Teachers' responses suggest that time constraints were more at issue than lack of Internet access (the third most commonly cited impediment). Further, there is some indication that some teachers see more value in data collection than in data reporting.

Our site visits to five selected GLOBE schools provided examples of strategies that active programs are using to deal with the issues cited by teachers in the survey sample. Despite the varying grade levels and geographic variety in the schools we visited, we discerned common trends across the group of five. One of these threads was administrator support. All five of the GLOBE teachers at the case study schools had strong backing from their principals. This backing included not only financial support for attendance at training sessions and the purchase of needed equipment, but also cooperation in making arrangements for common teacher planning time, transportation to study sites, and general promotion of the program within the school community. Principal support helped GLOBE teachers at these schools reach out to their fellow teachers to join or support the program. In some cases, GLOBE protocols and learning activities were distributed across different classes. In other cases, other classes supported the program, for example, by making clinometers for use in taking biometry measurements. By involving multiple teachers in implementing GLOBE, the lead teachers at these schools were able to do more with the time they had available for GLOBE. These teachers were also able to "leverage" time with their students through creative classroom management techniques. They set up structures for small-group work, with students taking on specific roles and rotating through those roles according to a schedule. Once this was done, students could execute multiple GLOBE activities simultaneously, with their teacher rotating from group to group to troubleshoot any problems or uncertainties that arose. These student groupings also leveraged student expertise and areas of high interest, giving a wide range of students the chance to contribute based on their "specialties."

Case study teachers also increased time for GLOBE by designing activities in ways that did "double duty," preparing for or executing GLOBE activities while simultaneously addressing required elements in the locally mandated curriculum. One teacher, for example, went through the mandated curricula for three elementary grades, finding places where GLOBE fit and then teaching sample lessons in various classes illustrating techniques such as teaching decimals and percentages through GLOBE measurement activities. GLOBE's ongoing efforts to work with state education agencies to identify congruences between GLOBE content and activities and state standards in science, mathematics, and geography is likely to facilitate such mapping of GLOBE onto required curricula and to enhance administrator support and the frequency of multi-teacher implementation efforts. Finally, all of the teachers in our site visit sample found ways to provide a motivating local context for GLOBE. They presented GLOBE measures as a way to objectively study the impact that various activities in their area were or were not having on the quality of their local environment.

Student Learning

Teacher survey data, data reporting patterns in the Student Data Archive, and classroom observations all attest to the great variety of adaptations and the great range of intensities of implementation of the GLOBE Program. What students learn from the program will, of course, depend on what parts of the program are implemented, how they are implemented, and how GLOBE activities are related to other aspects of students' school experience. To obtain some insights into these areas, we conducted a study of the environmental reasoning and ability to use data to make reasoned decisions on the part of high school students involved in GLOBE to varying degrees. One group came from GLOBE high school classes that contribute an above-average quantity of data to the Student Data Archive. A second group came from classes contributing an average amount of data to the archive. The third group was comprised of students of high school teachers who had signed up for GLOBE training but had not yet taken the training or started the program. Students worked in groups of two or three on two online assessment tasks.

On the environmental awareness task (described in Chapter 7), GLOBE students were marginally more likely than non-GLOBE students to incorporate important environmental concepts in their descriptions of an environmental scene. The amount of GLOBE data that their class had gathered did not predict the performance of students within the GLOBE classes, however (in fact, students from "average" GLOBE classes tended to use more environmental concepts than those that reported large amounts of data). When the students were given a more prescriptive question, a request to describe the scene in terms of the water cycle, GLOBE students mentioned significantly more phases of the cycle than did students from the non-GLOBE classes.

The second assessment task asked students to use environmental data to select a site meeting a complex set of climate-related criteria for the winter Olympics. After making a selection, students were required to develop a presentation including at least two data graphs that would support their recommendation. Students from classes that reported large amounts of GLOBE data performed better on this assessment than the other two groups, which were similar. When student performance was related to teacher reports of class activity, we found that the classes that had reported large amounts of data also were more likely than the "average" implementers to engage in data analysis activities. These classes also did more investigations building on GLOBE and more exploration of the GLOBE Web site. With the small number of classes participating in this study, it is not possible to disentangle the influences of these different activities, but we can make the general observation that an elaborated version of GLOBE in which students not only spend more time collecting data but also analyze and interpret that data and develop their own investigations is more likely to support the development of general data-driven problem-solving skills.

GLOBE's Evolution

Our evaluation activities have provided a portrait of the GLOBE Program as it has emerged and evolved over time. In retrospect, the initial concept for the program was both powerful and idealistic. In practice, GLOBE has had to deal with the complexities of the education system, and these complexities, along with the wide disparities in local conditions and supports, have inevitably led to large variations in the way in which the program is implemented. With 20/20 hindsight, we can appreciate the fact that such variations were inevitable. GLOBE's flexibility and its promotion of local adaptation are elements in the program's popularity. Below we describe features of the program that have become more apparent after five years of implementation and that are stimulating a more complex, differentiated program philosophy.

Teachers and schools will have different levels of involvement. While offering some unique features and advantages, GLOBE is just one of many programs and sets of science resources available to teachers. Not only do teachers have the choice of whether or not to take GLOBE training, but once they have completed the training, they have the choice of whether or not to use program elements, and if they do use elements, the choice of when and how to integrate them into their other school activities. While there are significant numbers of teachers who adhere to the original conception of GLOBE as a continuous data collection activity (at least during the academic year), there are also many teachers who implement GLOBE for 10 weeks or less and even some who choose to use learning activities without any data collection at all. The emphasis on learning activities relative to that on data collection appears to be on the rise. This variability should not be construed as a bad thing, and certainly is inevitable within the context of teacher and local decision-making around education as practiced in the United States. An implication of this state of affairs is that the individual educational resources need to be sufficiently rich and sufficiently self-explanatory that they can stand on their own.

GLOBE scientists need to be actively involved in recruiting and supporting the schools that provide data useful for their investigations. Given the various intensities of classroom involvement in GLOBE data collection activities discussed above, GLOBE's achievement of its goal to contribute to scientific knowledge is likely to depend on the energy and success with which the GLOBE scientists stimulate and support classroom involvement with their protocols. While the great majority of teachers embarking on GLOBE have used at least some of the Atmosphere protocols, the other investigations initially were implemented at lower rates—much lower in the case of Land Cover/Biology and Soil. Principal investigators for these areas have found that they need to recruit and incent schools to use their data collection protocols. Personal contact with the scientists goes a long way toward maintaining school commitment and interest. Special events such as the MUC-athons staged by the University of New Hampshire team can create a sense of urgency around GLOBE activities that helps them compete with the many other events in the school calendar (e.g., end of term examinations, performances, holiday parties, standardized testing periods).

The involvement of multiple teachers at a given school opens up opportunities for GLOBE to serve as a unifying theme within the science curriculum. The original recruiting concept behind GLOBE was to train one teacher for each school. In this way, it was thought that training dollars could impact the largest number of schools and consequently the largest number of students. As the complexity of GLOBE implementation became apparent and teacher turnover rates were considered, the GLOBE Program began encouraging the training of multiple teachers from a given school. The data show that this trend toward training second and third teachers for a school, which was on the increase between Years 3 and 4, has continued to gather strength. Reports from the field suggest that the involvement of multiple teachers in GLOBE is creating opportunities for curriculum integration across subject areas and articulation across years. Students who are introduced to GLOBE and one of its investigations in earlier years can proceed to tackle new investigation areas and increasingly complex data collection protocols and analysis activities in more advanced grades. By organizing science instruction around GLOBE, schools have the opportunity to create what Jerome Bruner calls a "spiral curriculum," with concepts introduced in a fairly simple yet intellectually honest way in early years and then revisited and elaborated with new content in subsequent years.

Many elementary teachers need continuing support in the area of science content. GLOBE is a content-rich program, and this is all to the good as it is not possible to teach scientific inquiry in the absence of a content domain. Nevertheless, this situation poses challenges for many elementary school teachers who themselves have very minimal science backgrounds. The fact that GLOBE is also inquiry oriented raises further challenges because teachers cannot predict ahead of time all the conceptual content that will be relevant as the inquiry progresses (NRC, 2000). Within the United States, elementary school teachers comprise the largest group of GLOBE implementers. Strategies for supporting these teachers' access to science knowledge, whether through additional education for the teachers or through the involvement of GLOBE scientists or of partner organization staff, parents, or community members with scientific expertise, are important.

The technology infrastructure required by GLOBE has diminished somewhat as a barrier to implementation. When the GLOBE program started in 1995, issues surrounding technology use were prominent. Many teachers and administrators were attracted to GLOBE as an opportunity to do something educationally worthwhile with this new technology, the World Wide Web. Of those teachers who took GLOBE training during the first year but did not get the program going with their students, lack of Internet access was the most frequently cited barrier. This is no longer the case. Although teachers still may lack the convenient in-classroom Internet access they might want, lack of access is no longer among the top barriers cited by teachers who are not using the program. Lack of availability of Internet access when they wanted to send student data was third to lack of time and low confidence in the data's quality as a reason for not submitting data that had been collected. Nor is desire to try out a new technology frequently cited as a reason for getting involved with GLOBE. These changes are not surprising given the dramatic increase in Web-based educational activities and in the availability of Internet access within U.S. schools. (Many international partners choose schools with Internet access for GLOBE participation or arrange to get that access for them.) Between 1994, the year before GLOBE started, and 1999, the proportion of U.S. schools with Internet access rose from 35% to 95%. During the same time interval, the proportion of classrooms with access rose from 3% to 63%. GLOBE has benefited from this increased availability of technology and from the increased technology skills that students bring to their GLOBE work.

Efforts to relate GLOBE to state and local curriculum standards appear to be helping. GLOBE teachers continue to see fit with mandated curricula and assessment systems as an issue. With encouragement from the GLOBE Program office, U.S. partners have been mapping elements of GLOBE onto their state standards and sharing these mappings with their teacher trainees. As described in our case studies (Chapter 5), individual GLOBE teachers are also taking on this challenge. In addition, SRI is developing a crosswalk between GLOBE elements and the National Science Education Standards. Given the pressures that teachers face to cover a broad curriculum, such efforts are necessary if GLOBE is to find a significant place within regular classes. International partners also report that as national curriculum frameworks are being revised in directions that make them more "GLOBE friendly," opportunities to incorporate GLOBE into regular classes are increasing.

Summary

GLOBE has evolved in terms of the breadth and nature of its offerings, the range of implementation models it can support, and its basic teacher recruiting and training strategy (i.e., the shifts to multiple teachers per school and to the use of training partners). The less commonly taught and newer data collection protocols and associated learning activities are starting to penetrate GLOBE classrooms, largely through the efforts of recently trained teachers, many of whom appear to be focusing on protocols not used by others at their school. Learning activities have become nearly as common as data collection protocols in the program as implemented by recently trained teachers.

With all these changes, GLOBE's basic concept, the involvement of students and teachers in real scientific investigations, has not changed. The program is continuing its efforts to further enhance both the scientific and the educational value of this enterprise.

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APPENDIX:

GLOBE 2000 Teacher Survey

OMB No. 0648-0310
Approval Expires: March 31, 2003

A SURVEY OF TEACHERS PARTICIPATING IN THE GLOBE PROGRAM

GLOBE Teacher Survey

Name: ______________________________________ Today's Date: ____________
(month/day/year)

Part A

A.1 Which category best fits your school? ***(If your school covers several of these categories, select the level at which students are most active in GLOBE.)***

Category *(Circle one.)*	
1	Elementary (Grades K-5, ages 5-10)
2	Middle or Junior High (Grades 6-8, ages 11-13)
3	High School (Grades 9-12, age 14 and up)

A.2 When and where did you receive your GLOBE training?

______________ Month ________ Year ______________________________________ Location

A.3 Think about the GLOBE training you received. How much emphasis was given to each of the following? ***(Circle one number for each item.)***

Scale:	*No training provided in this area*	*Minimal emphasis*	*Moderate emphasis*	*Strong emphasis*
	0	*1*	*2*	*3*

A. Atmosphere Investigation				
a. Atmosphere Protocols	0	1	2	3
b. Atmosphere Learning Activities	0	1	2	3

B. Hydrology Investigation				
a. Hydrology Protocols	0	1	2	3
b. Hydrology Learning Activities	0	1	2	3

C. Land Cover/Biology Investigation				
a. Land Cover/Biology Protocols	0	1	2	3
b. Land Cover/Biology Learning Activities	0	1	2	3

D. Soil Investigation				
a. Soil Protocols	0	1	2	3
b. Soil Learning Activities	0	1	2	3

E. GPS Investigation				
a. GPS Learning Activities	0	1	2	3

F. Seasons Investigation				
a. Seasons Learning Activities	0	1	2	3

G. Web Activities				
a. Use of Data Archive	0	1	2	3
b. Use of Visualizations	0	1	2	3
c. Use of MultiSpec	0	1	2	3
d. Use of the Student Investigations Journal	0	1	2	3

A.4 What are the *three* most important things you learned from the GLOBE training workshop you attended?

(1) ____

(2) ____

(3) ____

A.5 Since being trained in GLOBE, to what extent have you made each of the following changes in your teaching practices ***as a result of your GLOBE training experience? (Circle one for each line.)***

		Not at all				Great extent
a.	I have used some GLOBE-related explanations and examples in my teaching.	0	1	2	3	4
b.	I have used GLOBE material to teach topics I was teaching before with other materials.	0	1	2	3	4
c.	I have introduced new topics based on GLOBE into my curriculum.	0	1	2	3	4
d.	I have incorporated more hands-on science activities.	0	1	2	3	4
e.	I have given more emphasis to observation and measurement.	0	1	2	3	4
f.	I have given more emphasis to data analysis.	0	1	2	3	4
g.	I have had students design and conduct science investigations.	0	1	2	3	4
h.	I have had students use Web-based science resources.	0	1	2	3	4
i.	Other. *Please describe:* ______________________	0	1	2	3	4

A.6 Which forms of support has your school received from the organization that provided your GLOBE training? ***(Circle all that apply.)***

1 Teacher listserv

2 Meetings, conferences to share experiences

3 Local GLOBE newsletter

4 Supplementary materials (e.g., implementation tips)

5 Personal contact with franchise/program staff through phone or e-mail

6 Site visits by franchise/program staff

7 Visits by designated GLOBE mentor or master teacher

8 Arranged contacts with scientists

9 Refresher training sessions

10 Participation incentives (e.g., equipment or recognition in return for reporting certain types or amounts of data)

11 Monitoring and recognition for data reporting contributions

12 Other. *Describe:*________________________

____

13 None of the above

A.7 Were you involved with the GLOBE program in school year 1999-2000?

❒ Yes ➔ In what ways were you involved?

____

____

❒ No ➔ *Please skip to question A.9.*

A.8 Did you use any part of GLOBE with students during school year 1999-2000?

❒ Yes ➔ *Please skip to Part B of this survey on page 5.*

❒ No ➔ *Please continue with question A.9*

A.9 Have you used GLOBE with students in previous years (before school year 1999-2000)?

❒ Yes ➔ *Please continue with question A.10.*

❒ No ➔ *Please skip to question A.11.*

A.10 What caused you to suspend GLOBE-related teaching?

____

____

A.11 How important was each of the following potential barriers in keeping you from implementing GLOBE with students in 1999-2000? ***(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.	Concern about taking time away from instruction on material in mandated tests and curriculum standards.	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

A.12 Do you have plans to use any part of GLOBE with students at a future time?

❒ Yes ➔ *Please describe your plans.*

____

____

❒ No ➔ *Please explain your reasons.*

____

____

Thank you very much for your help in completing this survey. If you have any further comments, you may use the space on page 11. Please use the enclosed business reply envelope to return the survey to:

GLOBE Evaluation
SRI International
Room BN 257
333 Ravenswood Avenue
Menlo Park, CA 94025
USA

Part B

GLOBE IMPLEMENTATION AT YOUR SCHOOL

B.1 Including yourself, how many GLOBE-trained teachers were at your school in 1999-2000?

Number of GLOBE teachers: _______

B.2 Which GLOBE activities did you personally implement with students in 1999-2000, and which activities were implemented by other teachers at your school? ***(Circle all that apply.)***

		You implemented	Other teachers at your school implemented
a.	Take GLOBE measurements.	1	2
b.	Enter GLOBE data on the computer.	1	2
c.	Explore information on GLOBE Web site.	1	2
d.	Analyze, discuss, or interpret GLOBE data.	1	2
e.	Telecommunicate with other GLOBE schools.	1	2
f.	Engage in GLOBE learning activities.	1	2
g.	Student investigations building on GLOBE.	1	2
h.	Collaborative projects with other GLOBE schools.	1	2

B.3 For those activities your school 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.	Difficulty integrating GLOBE into existing curriculum.	1	2	3
f.	Concern about taking time away from instruction on material in mandated tests and curriculum standards.	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

GLOBE CLASSROOM ACTIVITIES

B.4 How many students participate in GLOBE in your school? ________________ in whole school

How many students participate in the *single class* or other setting in which *you* do the most GLOBE-related work with students? (Note: If you do GLOBE activities in more than one class or setting, please refer to the *single* class or setting in which you do the *most* GLOBE-related work with students.)

_______________ students in your single most active class or other setting

B.5 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 group, club, or after-school interest group	7 Middle or secondary lunch group, club, or after-school interest group
4 Other elementary: ____	

B.6 During a typical week, how do you organize your students for GLOBE activities in this *single* class or setting? ***(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	An adult does this (students don't)	We don't do this activity
a. Take GLOBE measurements.	1	2	3	4	5	6
b. Enter GLOBE data on the computer.	1	2	3	4	5	6
c. Use GLOBEMail or other resources on the GLOBE Web site.	1	2	3	4	5	6
d. Analyze, discuss, or interpret GLOBE data.	1	2	3	4	5	6
e. Engage in GLOBE learning activities.	1	2	3	4	5	6

B.7 In a typical week, how many hours do you spend:

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

Number of hours: ________

b. Planning or preparing for these GLOBE activities?

Number of hours: ________

B.8 During school year 1999-2000, how many weeks will students in your *single* most active class or other setting participate in GLOBE activities?

Number of weeks: ________

B.9 How often have you or your students used the following 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	0	1	2	3	4
b.	Visualizations	0	1	2	3	4
c.	Data Archive	0	1	2	3	4
d.	GLOBEMail	0	1	2	3	4
e.	Web Chats	0	1	2	3	4
f.	Student Investigations	0	1	2	3	4
g.	Online Teacher's Guide	0	1	2	3	4
h.	Resource Room	0	1	2	3	4

B.10 Do you consider data reporting to be educationally important for your students?

❐ Yes ➔ *Please describe why.*

____

____

❐ No ➔ *Please describe why.*

____

____

B.11 Have your students collected GLOBE data that did *not* get submitted to the GLOBE Data Archive?

❐ Yes ➔ *Please go on to Question B.12.*

❐ No ➔ *Please skip to Question B.13.*

B.12 For the data your school did *not* submit, which of the following were reasons?
(Circle one number for each reason.)

		Not a reason	Minor reason	Major reason
a.	Difficulty finding time to submit the data to the archive.	1	2	3
b.	Internet connection not working or unavailable.	1	2	3
c.	Lack of confidence that the measurements were taken properly.	1	2	3
d.	Belief that value lies more in taking the data than in reporting it.	1	2	3
e.	Delegated data reporting to others who did not get it done.	1	2	3
f.	Other. *Please describe:* ______________________________	1	2	3

B.13 Which, if any, of the following GLOBE protocols did you and/or another teacher at your school implement with students in 1999-2000? ***(Circle one for each protocol.)***

Scale:	*My school is NOT implementing*	*I am implementing*	*Another teacher is implementing*	*Another and I are both implementing*
	0	*1*	*2*	*3*

A. Atmosphere Protocols					**B. Hydrology Protocols**				
a. Cloud Type	0	1	2	3	a. Water Temperature	0	1	2	3
b. Cloud Cover	0	1	2	3	b. Dissolved Oxygen	0	1	2	3
c. Rainfall	0	1	2	3	c. pH	0	1	2	3
d. Precipitation pH	0	1	2	3	d. Alkalinity	0	1	2	3
e. Solid Precipitation	0	1	2	3	e. Electrical Conductivity	0	1	2	3
f. Max/Min and Current Temperatures	0	1	2	3	f. Water Transparency	0	1	2	3
					g. Salinity	0	1	2	3
					h. Salinity Titration	0	1	2	3
					i. Nitrate	0	1	2	3

C. Land Cover/Biology Protocols					**D. Soil Protocols**				
a. Qualitative Land Cover	0	1	2	3	a. Soil Characterization Field Measurements	0	1	2	3
b. Quantitative Land Cover (forest, woodland, or grass land)	0	1	2	3	b. Soil Characterization Lab Analysis	0	1	2	3
c. Biometry	0	1	2	3	c. Gravimetric Soil Moisture	0	1	2	3
d MUC System	0	1	2	3	d. Gypsum Block Soil Moisture	0	1	2	3
e. Land Cover Mapping (manual or unsupervised)	0	1	2	3	e. Infiltration	0	1	2	3
f. Accuracy Assessment	0	1	2	3	f. Soil Temperature	0	1	2	3

B.14 What are the *three* most important factors leading you to implement the protocols you do and not others?

(1) ____

(2) ____

(3) ____

B.15 In which GLOBE investigation areas, if any, did you implement GLOBE learning activities with students in 1999-2000?

	I did implement	I did NOT implement
a. Atmosphere Learning Activities	1	2
b. Hydrology Learning Activities	1	2
c. Land Cover/Biology Learning Activities	1	2
d. Soil Learning Activities	1	2
e. Seasons Learning Activities	1	2
f. Global Positioning System Learning Activities	1	2

B.16 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.17 How much has GLOBE helped students in your single most active GLOBE class or other setting 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.18 How much has GLOBE increased your students' knowledge in the following areas? ***(Circle one number for each area.)***

		Not at all	Not very much	Some-what	Very much	Don't know
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.	Earth as a system	1	2	3	4	9
f.	Global Positioning System	1	2	3	4	9
g.	Seasonal cycles	1	2	3	4	9
h.	Geography	1	2	3	4	9

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

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

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GLOBE Evaluation
SRI International
Room BN 257
333 Ravenswood Avenue
Menlo Park, CA 94025
USA