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Melding Authentic Science, Technology, and Inquiry-Based Teaching: Experiences of the GLOBE Program

Barbara Means[1]

Initial findings from the evaluation of the GLOBE Program are used to shed light on three issues concerning student-scientist partnerships: (1) Can students and scientists both derive genuine benefits from such partnerships? (2) What does technology add to efforts to bring authentic science into schools? (3) What is the relationship between student-scientist partnership programs and education reform efforts? Tensions between the goals of science and those of education are discussed and strategies for balancing conflicting requirements described. Both pragmatic and motivational benefits of technology use are cited. Although the evaluation of GLOBE's first year did not find evidence that student-scientist partnerships are sparking a transformation in teaching approaches, such programs provide a supportive context within which teachers seeking to align their practice with education reform principles may do so.

KEY WORDS: Evaluation; science education; GLOBE Program.

BACKGROUND

Advocates of science education reform are calling on schools to engage students in *doing* science rather than simply studying it (AAAS, 1993). Constructivist theory and the influential concept of "cognitive apprenticeship" (Collins *et al.*, 1989) provide support for this position. Certainly, involving students in scientific investigations can improve on the dry, vocabulary driven approach characteristic of so much elementary and secondary science instruction. But despite the strong interest (at least among the educational research community) in providing authentic science inquiry experiences for students, the field has yet to achieve a clear, shared understanding of the essential characteristics of "authentic science" within the context of K-12 educational settings.

The articles in this volume suggest that partnerships with practicing scientists are an important strategy for involving students in real science. The present paper differs from the other articles in that it is written from the perspective of a program evaluator, rather than a program designer. The experiences of the first two years of the Global Learning and Observations to Benefit the Environment (GLOBE) Program will be examined in light of three sets of interrelated questions. First, if the word *partnership* in student-scientist partnerships is strictly construed, the implication is that both parties must derive benefit from long term interaction. Thus, the student-scientist partnership model raises the question of whether students can derive benefits for their goals as students while scientists derive benefits for their roles as scientists (as opposed to as parents or as philanthropists).

A second issue concerns understanding the contribution that technology makes to students' involvement in authentic science. There is widespread belief that the use of technology should be part of science education (National Research Council, 1996) but less clarity about the contributions that technology can

[1]SRI International, 333 Ravenswood Avenue, Menlo Park, California 94025.

make. Do we have evidence to justify not just the dollar cost of technology purchase and implementation but the devotion of science class time to learning to use software tools?

Finally, student involvement in scientific investigations needs to be examined from an education reform perspective. One could argue that projects based on such investigations will never be implemented on a wide scale because they are fundamentally incompatible with the structures and schedules of conventional schooling. Alternatively, such investigations are sometimes viewed as a catalyst that eventually will lead schools to restructure themselves to accommodate more inquiry-based activities. What evidence do we have concerning the impact that inquiry-based science programs are having on classroom practices beyond the confines of the program itself? Is there evidence of influence spreading beyond individual classrooms to change schools and districts?

LESSONS FROM THE GLOBE EXPERIENCE

The GLOBE Program is described in some detail elsewhere (Rock *et al.*, 1997; Rock and Lawless, 1997; others, this volume), but some historical background may help explain its prominence as an example of students and scientists in partnership. Because the program concept originated with then Senator Gore (Gore, 1992) and developed with Vice President Gore's strong backing, it garnered a level of support and visibility across federal agencies that is unusual for a science education program. An interagency team including the National Oceanic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and the Departments of Education and State worked together to set up and staff the program. Teams at both NOAA and NASA worked to create the software for student data entry and the student data archive, World Wide Web site, and data visualizations. Vice President Gore sent letters to heads of state of 183 countries around the world inviting them to participate in GLOBE, and by June of 1995, more than 100 countries had expressed interest. In its first year, the program held 3 day teacher training sessions, each staffed by two scientists, a technology specialist, and two educators, for more than 1,500 teachers at sites around the U.S., as well as sessions in four international locations. This model is far from the typical NSF funded technology supported science education program, which begins with a handful of classrooms, adds a few more by the end of the first 3 year grant, and attempts a modest scale-up as part of a follow-on grant.

In 1995, SRI International was selected by the GLOBE Program as its evaluation partner. Although the program continues to evolve and seek to improve itself, the scope of this project justifies examination of the current GLOBE experience for what it can tells us about student-scientist partnerships. The data cited in this article are drawn primarily from surveys and site visits conducted in the spring of 1996 (the latter part of the first full academic year of GLOBE implementation). Several teacher samples were surveyed. First, a random sample of 400 teachers was drawn from the roster of U.S. teachers trained by GLOBE during 1995. Realizing that many trained teachers may have implemented only a small part of GLOBE during the first year, we also wanted to obtain a fuller picture of how the program operates when it is more fully implemented. We identified all GLOBE teachers whose schools were active in submitting three or more types of GLOBE data (air temperature, water temperature, and cloud cover) between January and March 1996. Among U.S. GLOBE schools, 250 met our criterion for active submission of GLOBE data; among international partner schools, 30 did so. The teachers for these schools were surveyed to obtain a portrait of what GLOBE looks like when it is implemented in some depth. Those teachers in this active data provider group whose students were in the 4th, 7th, or 10th grade were asked to administer a Student Survey to students in their single most active GLOBE class or club. In addition, site visits were conducted at five U.S. schools believed to be implementing GLOBE in a serious way on the basis of their data submissions or reports from GLOBE Program staff or scientists. The evaluation methodology and findings are described in detail in the GLOBE Year 1 evaluation report (Means *et al.*, 1996).

Feasibility of Genuine Student-Scientist Partnerships Based on Student Collection of Data

From its outset, GLOBE was conceived as a science and education program (as opposed to a science education program) that would promote the use of student-collected data by members of the scientific research community. The intent was to give equal weight to the goals of science (add to the knowledge and databases of earth science) and those of education (increase students' and teachers' awareness of environmental issues and students' knowledge and skills in science and related mathematics). Thus, a genuine partnership was the goal from the outset, and I believe that the nature of scientists' involvement in shaping GLOBE sets it apart from many other science education programs. Scientists held at least equal sway with science educators in the initial science workshop to identify areas where students could make measurements both to advance their own understanding and to enhance the scientific database about our globe. As a result, a measurement area such as soil moisture, which is not usually included in the K-12 curriculum but where there is a scarcity of data and hence an opportunity to contribute data of real scientific significance, found its way into the GLOBE Program. At the same time, measurements were included that, although widely available from other sources for most of the U.S. (i.e., temperature and precipitation), are straightforward to implement, require only inexpensive equipment, and fit well with a number of curricula at different grade levels.

Given the serious intention to use the data gathered by students, GLOBE had to be more vigilant about the standardization of procedures and equipment than is typical in science education programs. The first edition of the GLOBE Teacher's Guide was long on documentation of instrument specifications, calibration processes, and data collection protocol procedures, compared with many science education programs, and somewhat terse in terms of conceptual background for the investigations. Moreover, virtually no direction was provided in terms of classroom management techniques for hands-on science, in contrast to the teacher materials provided in connection with other hands-on science curricula, such as the Full Option Science System (FOSS) materials or Global Lab (Robardy *et. al.*, 1994; TERC, 1993–94).

While the GLOBE Program was gearing up for its training with an initial set of protocols ("GLOBE Phase I") and first-edition Teacher's Guide, it was also laying the groundwork for a second phase to involve an expansion of scientific investigations, educational activities, and curriculum integration and evaluation activities. In November 1994, the National Science Foundation issued an announcement inviting proposals from teams of scientists and educators interested in shaping the GLOBE Phase II investigations. Teams were sought to design scientific investigations in the areas of atmosphere/climate, trace gases, water chemistry, hydrology (water cycle), biometry, soil, and land cover, and to develop educational activities involving the understanding and use of global positioning systems (GPS). Each scientific investigation team was to be headed up by a scientist principal investigator (PI) committed to using GLOBE data in his or her research and to collaborating with an education co-PI who would help develop educational activities that would put the data collection and analysis activities into a meaningful educational context. After selection of the grantees, work on the Phase II materials began in May 1995 and continued through July of the next year, when the first draft of the second edition of the Teacher's Guide became available for training teachers in the summer of 1996.

The GLOBE vision certainly calls for a true student-scientist partnership. Students are part of real investigations designed by scientists who have a genuine stake in achieving a good outcome (usable data) from the enterprise. Thus, GLOBE was intended to provide the kind of "authentic" activity within schools that reformers advocate. It is still too early for definitive judgment about whether GLOBE as enacted fulfills its goal of a true partnership. We do not yet know the extent to which GLOBE data will be used by scientists and will lead to new insights about earth systems. The Phase II protocols, for which there is deep "ownership" by science principal investigators, are just now reaching the implementation stage (in the latter part of school year 1996–97). Over the next several years, the scientists will be surveyed and interviewed and publications using GLOBE data documented to try to shed light on this issue.

We can say something at this stage, however, about the sense of a real partnership from the student perspective. Evaluation data collected in the program's first full year of operation suggests that the partnership with scientists is a very important part of the GLOBE Program's appeal to students. The spring 1996 survey of 4th, 7th, and 10th grade students in active U.S. GLOBE classrooms found that 93%, 61%, and 76%, respectively, believed that the measurements they took were important for scientists. These same sentiments were expressed in focus groups of students drawn from GLOBE schools visited by the evaluation team. As one 6th grader put

A major thrust within this sixth-grade classroom is the teaching and learning of concepts of data reliability and accuracy. The fall and spring collections of GLOBE biometric data provided a context for instruction in these areas. Ten small groups each measured the height and diameter of a specified tree and independently took measures of the canopy and ground cover. The measurements were brought back into the classroom for review and discussion.

The tree measurements were dealt with as an extension of prior measurements. In October, the students had compared the data collected that month to the measurements taken in April 1995 and pursued a number of questions concerning how trees grow. The data collected in April 1996 were compared to October 1995 data and to that for April 1995. The rates of change in the two time intervals were compared. A summary of the class findings, taken from one student's science journal, is shown below.

Height	May - Oct	Oct - April
Bottle Brush:	15%	6%
Chinese Pistachio:	14%	8%
Canary Island Pine:	8.7%	2%
average	14%	5.3%

Diameter	May - Oct	Oct - April
B.B.:	4%	1.6%
C.P.:	14%	7.75%
C.I.P.:	8.7%	4.8%
average	9.4%	5%

Reasons why trees might grow more from May to October than from October to April were discussed. The class also compared growth estimates based on tree height with those based on diameter. A number of trees that appeared to "shrink" on the basis of the height estimates showed growth in terms of diameter. The teacher suggested that the latter appeared to be a more reliable measure of growth.

The ten independent ground cover and canopy measures were all projected on a screen in front of the class to permit scrutiny and averaging before determining the measures to report to GLOBE. The class reviewed the concepts of mode, median, range, and mean and discussed the best measure to use. The students were clearly highly motivated to produce accurate data and engaged in lively discussions comparing the readings obtained by different individuals or groups and assessing the acceptability of a given measurement. One student group had a ground cover estimate much lower than that of the other groups. The class noted the discrepancy and asked about the procedure used to take the measurement. Upon finding that it did not match the protocol precisely, they decided that the measurement should be thrown out before the group readings were averaged.

The next day, a student from this same class applied a similar critical stance to reviewing the data provided by others. While looking at GLOBE biometric data from the archive, he noticed that one school had reported a tree over 70 meters high.

The student pointed out this entry in the GLOBE database, "A tree over 200 feet high in Massachusetts? I don't think so!" The student went on to discuss the entry with several peers. They reasoned that only a redwood could be that high (a correct assumption unless the Eastern class is monitoring an old-growth stand) and redwoods don't grow in the Eastern U.S. The students pointed out the anomaly to their teacher who suggested they e-mail the school that had made the measurement.

Fig. 1. Snapshot of a GLOBE class in action.

it, "I feel like we proved what we can do . . . that we're real scientists."

Another indication of the motivational value of partnering with scientists in our student survey results was the large proportions of students who agreed with the statement that the GLOBE Program will help people better understand the earth (93%, 72%, and 75% of 4th, 7th, and 10th graders, respectively). The belief in the importance of their data as part of a real investigation pushes students to examine the quality of the data their class is collecting and, at least in some of the GLOBE classrooms we observed, can lead to sophisticated conversations about measurement procedures and statistical concepts such as variance and outliers. Figure 1 describes the kinds of activities GLOBE sparked in a class of 6th-graders.

At the same time, it should be acknowledged that the GLOBE Program pays a price for attempting a partnership based on the value of the student data. From an educational standpoint, it could be argued that, at least for the types of data collected on a daily schedule, learning derived from participation in the data collection per se reaches a point of diminishing returns after a certain number of repetitions. Some teachers express this opinion explicitly; more reflect it in their actions. We are finding that teachers who begin implementing GLOBE do not necessarily continue GLOBE activities without interruption. A common pattern is implementation of the atmosphere protocols during the fall semester, when the class is studying weather, with a cessation of activities or a move to different GLOBE protocols in the spring. From a teacher's perspective, such selective implementation is desirable, since teachers feel the press of limited time and broad curriculum requirements. From the scientist's perspective, of course, such discontinuities seriously reduce the value of the resulting data set.

Another limitation of the type of student-scientist partnership GLOBE represents is the extent of focus on data collection, with relative neglect—at least during the program's first year—of other aspects of scientific inquiry. Programs with less of a stake in producing new scientific knowledge have an easier time involving students extensively in posing hypotheses, designing data collection procedures, and analyzing data.

The discussion above highlights the very real tension between some of the goals of science and those of education; nevertheless, I do not believe that the two sets of needs are irreconcilable. To the extent that the scientists' partnership with students can go beyond the design of protocols and collection of data to include students in timely interpretation and use of the data, students and teachers can be motivated to continue with investigations (and outgrowths of investigations) for longer periods. GLOBE has taken steps to increase the level of interaction between students and scientists, with innovations such as a Scientist Corner on the GLOBE Web site and personal messages from and interviews with the scientist PIs incorporated into the second-edition Teacher's Guide. Nevertheless, more synchronous (or nearly so) communication and more information for teachers and students about just how their data are being used will be critical for sustaining interest in the program. During the second year, the program began experimentation with scientist on-line sessions. Such activities make significant demands on scientists' time, however, and although we have some precedents (Gordin *et al.*, 1996; Linn, in press), there is still much to learn about how best to structure them.

Other possible strategies for reconciling teachers' need to "cover" more curriculum with scientists' needs for continuity and completeness in the data set include (1) moving toward a schoolwide or districtwide implementation mode in which different groups of students or classes collect the data at different points during the year but continuity for the jointly developed data set is maintained and (2) designing enhancement activities around the data collection that link to widely adopted curriculum standards in science and mathematics. GLOBE-related enhancement activities focusing on different aspects of science and mathematics could be initiated throughout the school year, justifying continuing student involvement in collecting data. For example, a class's GLOBE data set can serve as an excellent context for teaching concepts related to statistics and probability, as urged by the National Council of Teachers of Mathematics (NCTM) standards.

Technology's Role in Supporting GLOBE

Another question raised by the GLOBE Program is the role that technology plays in supporting student-scientist partnerships. From the beginning, Vice President Gore and the GLOBE Program developers wanted the program to demonstrate the power of the Internet as an infrastructure for sharing data. Web-based forms were developed for students to use in reporting their GLOBE data. A GLOBE Web site was developed to include links to these forms as well as to the archive of all GLOBE data, visualizations of GLOBE data, listings of GLOBE schools, and a section highlighting GLOBE "stars" (programs that have reported a large amount of data). Software ("MultiSpec") was made available for manipulating satellite images of a GLOBE school's study area.

During the program's first year, a GLOBEMail feature was implemented as part of the GLOBE Web site. This enabled GLOBE schools to send messages to other GLOBE schools, and in some cases interesting dialogues emerged concerning issues such as ground-level ozone or extreme weather events around the globe. The exchange of data or other joint activities with distant schools was not part of the data collection and educational activities supported by GLOBE Phase I teacher training and instructional materials, however. Moreover, because many GLOBE classrooms have only limited access to an Internet-capable computer, GLOBEMail messages to other schools often went unanswered. Like other telecommunications-supported education projects, GLOBE found that simply providing the technical facility was not enough. An infrastructure that includes suggestions for interesting cross-school activities and some help in finding appropriate partners is needed also. (Many programs provide a moderator for Internet-based discussions.) In GLOBE's second year, several joint activities for two or more schools were developed and recommended as educational activities. In addition, a "matchmaking" function for GLOBE schools seeking partner schools was set up.

GLOBE's use of technology was a draw for many teachers entering the program. Some were at schools receiving new Internet connections and were eager to launch a worthwhile educational program that relied on the technology. Some used the lure of the program as an argument for obtaining computers and/or Internet connections for their classrooms. On the other hand, assembling the required hardware

Table I. Problems Rated as "Major Barriers" by 90 Trained Teachers Who Had not Implemented GLOBE with Students[a]

Barrier	Percent Reporting
Lack of Internet access	46
Lack of time to plan and implement	37
Lack of phone line	31
Difficulty fitting into school schedule	27
Lack of computer hardware/software	20
Difficulties integrating into existing curriculum	18
Difficulty identifying an appropriate site	13
Lack of technical support	12
Lack of confidence in ability to take measurements correctly	4
Concern about whether GLOBE would be valuable for my students	4

[a]Sample sizes: $80 \le n \le 85$.

and software and arranging for Internet connections was a barrier that slowed many teachers' implementation of the program. The problem was exacerbated during the first part of the year because many of the technology tools were in a state of flux. Of those teachers trained by GLOBE during 1995 who had not started to implement the program by April 1996, lack of Internet access was the barrier most frequently cited (by 46%). Among those who had implemented the program, getting access to adequate computers and getting computer technical support were seen as "major challenges" by 25% and 24%, respectively. For teachers with little technology background or support within their schools, the technical requirements of GLOBE can be daunting. Table I summarizes the reports of U.S. teachers trained in GLOBE but not implementing the program concerning the reasons they had not started using GLOBE with students. Table II summarizes the responses of teachers who were implementing the program when asked to rate the degree of challenge posed by various aspects of the program.

Certainly, science data can be collected and reported through other means (telefacsimile, mailed report), as some countries without reasonable access to the Internet are doing. But to a major extent, reporting data through the Internet and accessing the GLOBE Web site to find the data you submitted earlier in the week are important parts of what makes the program "real" for students. In the spring 1996 Student Survey, technology use was the aspect of GLOBE receiving the highest student approval rat-

Table II. Factors Rated as "Major Challenges" by Teachers Implementing GLOBE[a]

Challenge	Percent of Trained Teachers Reporting	Percent of Active Data Providers Reporting
Accessing instruments for data collection on weekends, vacations	50	45
Fitting activities into school schedule	45	35
Finding time for GLOBE, given other curriculum and testing requirements	42	37
Finding time to prepare for implementing GLOBE	40	33
Getting to the data collection site	30	21
Getting access to adequate computers	25	17
Getting computer technical support	24	10
Logging onto GLOBE server	23	12
Assessing what students are learning from GLOBE	22	19
Integrating GLOBE with the rest of the curriculum	20	18
Securing GLOBE equipment	19	19
Finding funds to purchase scientific measurement instruments	14	14
Presenting activities at right level for students	14	11
Obtaining support from administrators, other teachers	13	11
Getting measurement equipment to work properly	8	4
Maintaining good student behavior during GLOBE activities	8	4

[a]Sample sizes:Trained teachers, $173 \le n \le 216$; active data providers, $197 \le n \le 221$.

Table III. Aspects of GLOBE that Students "Like a Lot"[a]

Aspect of GLOBE	4th Grade	7th Grade	10th Grade
Putting GLOBE data on computer	81	58	56
Looking at satellite pictures	73	57	55
Taking measurements	70	52	46
Looking at GLOBE data collected by students in other places	56	27	35
Talking about weather, the earth, and water	55	29	34

[a]Sample sizes: 4th grade, $499 \leq n \leq 758$; 7th grade, $138 \leq n \leq 223$; 10th grade, $82 \leq n \leq 107$.

ing, with 81% of 4th graders, 58% of 7th graders, and 56% of 10th graders reporting they "like it a lot." (Table III provides the students' approval ratings for each program component on the survey.) Seeing their own contribution as part of a database inspected and analyzed by scientists and other students helps GLOBE students see themselves as part of a scientific community. Providing them with a good approximation of the tools used by scientists tells students that we regard their science activity as genuine and important.

STUDENT-SCIENTIST PARTNERSHIPS AND EDUCATION REFORM

Principals and teachers at sites visited by the evaluation team told us that they found GLOBE attractive because of its consistency with new science and mathematics curriculum standards and with principles of educational reform. GLOBE is clearly project based and engages students in hands-on science as they collect data for use in real investigations. Because it is grounded in authentic science, the program provides a rich context for introducing challenging material early in students' schooling. The discussions of standardization and data quality control in the 6th-grade classroom described in Fig. 1, for example, are surely unusual in precollege U.S. classrooms. The program is conducive also to cooperative learning and cross-age activities. GLOBE measurement activities are most easily done in small groups. Likewise, data quality techniques stress the importance of comparing independent measurements, identifying unreasonable data, and resolving discrepancies. Through such collaborations, students can learn from each other, as well as provide more and better data than could be expected from a single individual.

GLOBE's congruence with new standards and education reform efforts is one reason for teachers' enthusiasm and for the support GLOBE receives from school and district administrators. A GLOBE teacher in a recent phone interview reported, "A wonderful program. My school district is using it as a model for how the science curriculum should be." At the same time, however, we are finding that many schools are unwilling or unable to make the kinds of structural changes that would make participation in programs like GLOBE easier. GLOBE teachers find that the lack of block scheduling, interdisciplinary math-science classes, and Internet connections in classrooms make full realization of GLOBE's potential difficult. Because GLOBE is a science program, it has a data collection schedule congruent with the demands of science (atmospheric measurements are to be taken within an hour of solar noon every day). This schedule is clearly incompatible with the schedule of schools, i.e., with weekends, holidays, and summer vacations, as well as tightly scheduled academic periods. When asked to rate the severity of a variety of challenges to implementing GLOBE (Table II), teachers put the problem of collecting data outside the boundaries of the school schedule at the top of their list of challenges (with 50% citing it as a "major challenge").

GLOBE was designed in a fashion that provides sufficient flexibility to permit implementation in a broad range of grade levels and settings. Very traditional high schools as well as highly innovative private schools, reservation schools, and juvenile residential centers are implementing the program. Nevertheless, the fullest implementation of a program involving students in partnership with scientists engaged in scientific inquiry requires an amount of time and a flexibility of scheduling that only a minority of American schools appear willing to provide. Fitting GLOBE into the school's schedule of academic periods was cited as a "major challenge" by 45% of teachers in our survey sample. Finding time for GLOBE, given other curriculum and testing requirements, was considered a major challenge by 42% (Table II).

Another, emerging barrier is schools' susceptibility to the "innovation du jour" phenomenon. Several GLOBE teachers who were active in school year 1995–96 reported in phone interviews during winter 1996–97 that they had become less active because of competition from another "educational reform," such as a new state curriculum framework or a new set of science materials. As new district or state curricula or standards are released, often with considerable fanfare, some teachers feel that they have less latitude to incorporate GLOBE into their classes. In parts of the country where school districts or universities have begun to offer GLOBE training and to identify congruence between GLOBE activities and state or local curriculum frameworks, this concern may be ameliorated. The GLOBE evaluation will be examining this issue over the next several years.

We have some data relevant to the question of GLOBE's impact on individual teachers' pedagogy. Active GLOBE teachers visited by the evaluation team often designed cross-age activities centered on GLOBE and created connections across classrooms. Students in a GLOBE high school teach the GLOBE hydrology protocols to 4th-graders at a nearby elementary school, for example. In a middle school, the GLOBE teacher and the mathematics teacher delineated a whole set of mathematics objectives that could be taught through participation in GLOBE.

Typically, GLOBE schools began by trying out activities with a single grade level, but many have begun moving toward having students teach other students at a different grade level. The students providing the training profit from having to learn the procedures well enough to be able to demonstrate and explain them. Moreover, students enjoy the experience of being the source of knowledge for a change. Because GLOBE activities are quite amenable to training and don't require the years of practice that go into something like learning to read or mastering cursive writing, both the students being trained and those doing the training can quickly see the fruits of their labor. Thus, there are numerous examples of classrooms and schools with ongoing GLOBE-related efforts that are highly consistent with typical educational reform goals.

However, we have also observed classrooms in which thirty-some students sit at their desks and get quizzed by their teacher on the definitions of terms in the GLOBE protocols. Although at this point our conclusions must be tentative, it appears that GLOBE is a fertile outlet for the design and implementation of reform-oriented activities for teachers who are already so inclined, but it does not transform teachers' instructional approach. When the students whose class is described in Fig. 1, for example, were queried about whether their teacher uses different teaching approaches when doing GLOBE, they responded that he uses the same methods but is "more energetic" during GLOBE.

Looking at the program more broadly, the responses of students in our survey sample suggests that instructional practices during GLOBE are superior (in the sense of congruence with education reform prescriptions) to the other instruction they experience in some respects but inferior in others. Students report overwhelmingly that they do less answering of questions from a book or worksheet in connection with GLOBE (not surprisingly since neither is provided by GLOBE), do less learning of vocabulary at the middle and high school levels, and do more computer work at the elementary level. On the other hand, students report doing more work in a group with other students, peer tutoring, and independent problem solving during non-GLOBE activities. In terms of the impact of these differences in instruction on students, the students report being less likely to be confused about what they are supposed to do during GLOBE and less likely to be bored doing something they don't care about.

To say that we do not have strong evidence that programs such as GLOBE are a catalyst for education reform is not to denigrate their value as a fertile context for such activities. To the extent that such programs spark teachers' imaginations and provide them with resources for developing connections across academic disciplines and classroom boundaries and for involving students in genuine scientific inquiry, they provide an extremely valuable service.

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