Georgia Goes Global!

Monitoring the Global Environment through Authentic Science

The SOUTHEAST EISENHOWER REGIONAL CONSORTIUM for MATHEMATICS and SCIENCE EDUCATION at SERVE

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Monitoring the Global Environment through Authentic Science

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SERVE
Improving Learning through Research & Development

Associated with the School of Education
University of North Carolina at Greensboro

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The Southeast Eisenhower Regional Consortium for Mathematics and Science Education @ SERVE is one of ten regional consortia created by Congress to improve mathematics and science education throughout the nation. The Consortium has three objectives:

- Coordinating mathematics and science resources
- Disseminating exemplary mathematics and science educational instructional materials
- Providing technical assistance for the implementation of teaching methods and assessment tools for use by elementary and secondary school students, staff, and administrators

The Consortium frames its work through the following focus areas:

- **Collaboration and Communication.** Joining forces with other mathematics and science education organizations at the national, state, and local levels
- **Programs and Curricula.** Identifying and disseminating exemplary mathematics and science materials with and through the Eisenhower National Center and other educational agencies
- **Professional Development.** Providing for the training of teachers, administrators, and other trainers in the use of exemplary mathematics and science materials, methods, and assessments
- **Curriculum Frameworks.** Assisting in the development and implementation of standards-based state curriculum frameworks
- **Technology.** Facilitating the use of telecommunications technology as a tool for mathematics and science instruction
- **Equity.** Supporting programs and activities that meet the needs of underserved groups in mathematics and science
- **Informal Education Agencies.** Supporting the use of informal mathematics and science agencies through disseminating information and encouraging collaboration
- **Community Outreach.** Promoting dialogue with community groups to engage them in meaningful ways to support mathematics and science

We offer the following services to promote our objectives:

Networks

- Collaborating with existing networks of mathematics and science educators
- Building and supporting new networks
- Providing opportunities for educators to share ideas and observations about what works in mathematics and science education
- Sponsoring conferences, teleconferences, meetings, and symposia

Access to Promising Practices in Mathematics and Science

- Identifying successful mathematics and science programs
- Publishing information on effective programs

Technical Assistance

- Helping schools and districts adapt and use new programs, policies, equipment, and resources
- Identifying the training needs of mathematics and science educators
- Developing effective training to meet identified needs through a Technical Assistance Academy for Mathematics and Science Services (TAAMSS)

Resources

- Providing access to SERVE products and services
- Helping educators gain access to local, state, regional, and national resources

Free and Low-Cost Materials

- Developing practical resources schools can use, including publications, video tapes, resource lists, and policy briefs that address concerns from schools, districts, and state education agencies

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SERVE, directed by Dr. John R. Sanders, is an education organization with the mission to promote and support the continuous improvement of educational opportunities for all learners in the Southeast. The organization's commitment to continuous improvement is manifest in an applied research-to-practice model that drives all of its work. Building on theory and craft knowledge, SERVE staff members develop tools and processes designed to assist practitioners and policymakers with their work, ultimately, to raise the level of student achievement in the region. Evaluation of the impact of these activities combined with input from affected stakeholders expands SERVE's knowledge base and informs future research.

This vigorous and practical approach to research and development is supported by an experienced staff strategically located throughout the region. This staff is highly skilled in providing needs assessment services, conducting applied research in schools, and developing processes, products, and programs that inform educators and increase student achievement. In the last three years, in addition to its basic research and development work with over 170 southeastern schools, SERVE staff provided technical assistance and training to more than 18,000 teachers and administrators across the region.

SERVE is governed by a board of directors that includes the governors, chief state school officers, educators, legislators, and private sector leaders from Alabama, Florida, Georgia, Mississippi, North Carolina, and South Carolina.

At the core of SERVE's business is the operation of the Regional Educational Laboratory. Funded by the U.S. Department of Education's Office of Educational Research and Improvement, the Regional Educational Laboratory for the Southeast is one of ten programs providing research-based information and services to all 50 states and territories. These Laboratories form a nationwide education knowledge network, building a bank of information and resources shared nationally and disseminated regionally to improve student achievement locally. SERVE's National Leadership Area, Expanded Learning Opportunities, focuses on improving student outcomes through the use of exemplary pre-K and extended-day programs.

In addition to the Lab, SERVE operates the Southeast Eisenhower Regional Consortium for Mathematics and Science Education and the SouthEast Initiatives Regional Technology in Education Consortium (SEIR◆TEC). SERVE also administers a subcontract for the Region IV Comprehensive Center and has additional funding from the Department to provide services in migrant education and to operate the National Center for Homeless Education and the Adjunct ERIC Clearinghouse on Homeless Education.

Together, these various elements of SERVE's portfolio provide resources, services, and products for responding to regional and national needs. Program areas include Assessment, Accountability, and Standards; Children, Families, and Communities; Education Leadership; Education Policy; Improvement of Science and Mathematics Education; School Development and Reform; and Technology in Learning.

In addition to the program areas, the SERVE Evaluation Unit supports the evaluation activities of the major grants and contracts and provides contracted evaluation services to state and local education agencies in the region. The Technology Support Group provides SERVE staff and their constituents with IT support, technical assistance, and software applications. Through its Publications Unit, SERVE publishes a variety of studies, training materials, policy briefs, and program products. Among the many products developed at SERVE, two receiving national recognition include *Achieving Your Vision of Professional Development*, honored by the National Staff Development Council, and *Study Guide for Classroom Assessment: Linking Instruction and Assessment*, honored by Division H of AERA. Through its programmatic, technology, evaluation, and publishing activities, SERVE provides contracted staff development and technical assistance in specialized areas to assist education agencies in achieving their school improvement goals.

SERVE's main office is at the University of North Carolina at Greensboro, with major staff groups located in Tallahassee, Florida, and Atlanta, Georgia, as well as satellite offices in Durham, North Carolina, and Shelby, Mississippi. Unique among the ten Regional Educational Laboratories, SERVE employs a full-time policy analyst to assist the chief state school officer at the state education agencies in each of the states in the SERVE region. These analysts act as SERVE's primary liaisons to the state departments of education, providing research-based policy services to state-level education policymakers and informing SERVE about key state education issues and legislation.

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-—*Terrie Kielborn, Frank Orr, and Michael Childs*

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Foreword

By Francena Cummings, Ph.D.

"Professional curriculum and instructional standards in mathematics and science reflect a research-based understanding that learning is a process in which youngsters are active participants in the acquisition and construction of knowledge" (National Science Foundation, (NSF) July 1998, p.9). This quote illustrates the thinking that drives current science reform, which focuses on standards-based teaching, including inquiry, project-based activities, problem solving and other activities designed to engage students. While there are many teachers who embrace inquiry-based teaching, there is still the need to offer teachers opportunities to engage in inquiry-based experiences so as to raise their level of expertise with implementing dynamic tasks that engage students in learning about scientific phenomena

In this Monograph, *Georgia Goes Global* (Global Learning and Observations to Benefit the Environment (GLOBE), the co-authors offer a glimpse of students and teachers engaged in inquiry around environmental topics that are focused on the earth's system as a whole. Why is this kind of learning important to our students? What are the advantages of involving students in these experiences? Moreover, what lessons do teachers learn from teaching the *Georgia Goes Global*?

GLOBE is a great example of a partnership among federal programs, universities and local school systems to improve science education for K–12 students. GLOBE brings together scientists, science teachers and students for the purpose of advancing scientific understanding of the earth. This worldwide hands-on science program provides students with realistic experiences that connect to questions that they may have on the nature of intriguing environmental phenomena. From water quality to soil study, students engage in activities that allow them to learn by doing. They are able to do science through answering their own questions of interests; they used the processes of science to draw conclusions about scientific phenomena. Further they are able to use technology to access similar problems that other students discovered across the country as well as internationally.

Professional development for teachers must be a central part of the agenda for teacher change and the GLOBE project provides valuable learning opportunities that promote inquiry around arelevant issues in science education. Teachers who are involved in the GLOBE Project have experiential learning as they become familiar with the GLOBE protocols for the various topics. As one of the authors pointed out, the GLOBE training served as a scaffolding mechanism for extending or developing topics related to topics of the GLOBE protocols. Besides, they experience firsthand some of the new equipment that must be utilized in the protocols.

In this monograph, teachers offer artifacts from their learning and teaching experiences. These shared experiences remind us that learning is a personal journey; however, teachers continue to make a difference by setting the directions for the journey. Congratulations to the teachers and science educators who shared their stories. In the final chapter, the co-author delineates some of the impact that the project has had on the teachers and students. The one benefit is doing and talking science, important dimensions of helping students appreciate and value science.

“The Woes of Nature”

Written by Dennis V. Casey

Dennis Casey is a fifth-grade mathematics teacher at Chestnut Log Elementary School in Douglasville, Georgia. He has been teaching for seven years and holds an Education Specialist degree from the University of West Georgia.

I am Nature.
I am the atmosphere, the hydrosphere, the lithosphere, the
exosphere, and the biosphere.
I am the skies above
and the rocks and waters below.
I am the environcentric position that says that all things need
to center around and adapt to me.

I am a serial killer lurking in the rainforest.
I am a magician and an assassin.
I am Ebola.
I am now surfacing in the hearts of the cites
that once were the jaws of the jungles.

I am Global Warming.
My temperatures are ripe for the spread of disease.
Centuryly (Cent-chur-ree-lee),
my temperatures continue to rise degree by degree.
The summers are much warmer than they once used to be!

“I am barley breathing,”
I heard a human say to me.
Coughing and gasping,
just for a few,
precious morsels and breaths
of my O2.
But can I help it if there are more of thee,
than there are trees like me?
‘Cuz, I am Deforestation:
the depletion of forests for human consumption,
the destruction of habitats for lions and bats,
the loss of food for bears and emus,
and, the decreased support for the ground,
to which I’m bound.

I am Soil Erosion.
I watch flood waters roll past the former locales of absorbable
trees.
I am the washing away of dirt by the wind and the rain.
I am the rapid and continual change of the earth’s terrain.

I am Acid Rain.
I am sulfur and nitrogen emissions from
burned fossil fuels like oil and coal.

I am the exhaust of automobiles that
combine with water vapor in the clouds
to return to the earth as rain.
I lower the pH of lakes.
I corrode bridges, buildings,
and coaxial cable coils.
I help harm the soil.

My name is Ozone.
Which means,
Mother Nature’s “sunscreen.”
UV-B seeps through my CFC created hole,
to wreak havoc and cause turmoil.
The legacies I helped borne:
skin cancers, cataracts, genetic mutations, and attacks,
damages to several species of worms,
plus a host of other plant and marine life-forms,
have all caused me to be torn with scorn.

I am the honking of a horn,
the vroom and the zoom,
the pitter and the splatter,
and the boon and the doom.
Yes, you’ve probably guessed,
that I am the affliction,
properly known as Noise Pollution.
I am now playing in select areas,
but am spreading quickly to a town near you.

I am the Greenhouse Effect.
My gases,
like CO2,
allow light simply to pass right through.
So that it can change to heat as it strikes the ground.
But when it tries to rebound,
it gets knocked back down.

Causing the earth to feel too hot to trot.

I house cryptosporidium
and a host of other bacterium.
I am Water Pollution:
a major problem seeking a major solution.
I must be corrected,
or all will be infected.
Clean H2O,
is extremely valuable.

I am Over Population.
I am Malnutrition too!
I am Starvation and Limitation.
I am crowded on the top of Macchu Picchu.
I am Nuclear Waste.
I am Global Cooling.
I am Landfills at their capacity levels.
I am Recycling.
I am...
I am Nature.

Wouldn’t it be swell,
If we could all begin again?
Escape to the heavens,
and give manifest destiny a spin?
Will leaving the earth be a cure,
from the ever prevalent threat of nuclear war?
Our last effort pitch
may be to find a new niche
in the skies above.

The beginning.

Chapter One

The GLOBE as a Constructivist Learning Environment

By Frank Orr, Ph.D., Nancy Davis, and Michael Childs

> *Talking Science means observing, describing, comparing, classifying, analyzing, discussing, hypothesizing, theorizing, questioning, challenging, arguing, designing experiments, following procedures, judging, evaluating, deciding, concluding, generalizing, reporting, writing, lecturing, and teaching in and through the language of science. (Lemke, 1990)*

Prologue

Evolutionary changes that occur do so over spans of time or eras and are virtually unnoticed. Geological and anthropological studies have revealed artifacts verifying the existence and extinction of species, which may be attributed to many factors or conditions.

If the current trends continue, common sense dictates that these trends are on a collision course that will not only jeopardize basic human needs, but also the fundamental systems required to maintain global sustainability.

Dramatic evolutionary changes are usually associated with cataclysmic events that occurred prior to the existence of the human species. Environmentalists profess that contemporary issues pertaining to global sustainability have occurred very subtly due to the homocentric behavior of the human species creating an imbalance in nature. If the current trends continue, common sense dictates that these trends are on a collision course that will not only jeopardize basic human needs, but also the fundamental systems required to maintain global sustainability.

A new worldview will require a paradigm shift from a homocentric position to an environcentric position that perceives nature as the center, with humans needing to learn to adapt or accommodate to it. Based on this paradigm shift, GLOBE (Global Learning and Observations to Benefit the Environment) represents an excellent venue for K–12 students to perform authentic science and be instrumental in effecting change.

The GLOBE Program

The Global Learning and Observations to Benefit the Environment (GLOBE) Program is a unique hands-on international environmental science and education program designed for use in schools in kindergarten through grade 12. It brings together students, teachers, and scientists from around the world to

- Enhance environmental awareness.
- Increase scientific understanding of the earth.
- Support improved student achievement in science and mathematics (Finarelli, 1998).

Currently, participants in more than 10,000 schools in 96 countries take environmental measurements selected by the world science community to provide data useful for research into the dynamics of the earth's environment. Learning activities have been developed through data collection protocols designed by environmental scientists in the areas of Atmosphere/Climate, Hydrology, Land Cover/Biology, Soil, and Global Positioning Systems (GPS)/Remote Sensing.

Globe Students:

- Make environmental measurements utilizing the GLOBE protocols and calibrated measurement equipment providing a core set of environmental observations at or near their geographical region.
- Report their data through the Internet/World Wide Web to a GLOBE data processing facility.
- Receive global environmental images created from worldwide data.
- Interact with scientists and contribute their data to actual research.
- Study the environment by relating their observations and the resulting images to broader environmental topics (Finarelli, 1998).

GLOBE, therefore, is an international program in which school children, through hands-on measurements of their local environments, contribute to helping scientists better understand the earth as a "holistic" ecosystem.

Former Vice President Al Gore commissioned the program from an original concept first introduced in his 1992 book, *earth in the Balance*. This concept embodies the idea that today's young people will, as adults, greatly influence what life on earth will be like in the future. Being literate in science is a condition for doing so responsibly, as well as for living a full and meaningful life (AAAS, 1993). GLOBE, therefore, is an international program in which school children, through hands-on measurements of their local environments, contribute to helping scientists better understand the earth as a "holistic" ecosystem.

The Georgia Initiative

The premise is if students are exposed to real-life problems involving the environment, it serves to arouse their interest and to motivate them toward full participation as citizens in our technologically dependent society (Zinn, Gnut, & Zafkafi, 1999). Science teachers are being challenged to present science as it "really is," rather than promote a mythic, textbook science (Martin, Kass, & Brouwer, 1990). Increasingly, there is a call for developing scientific literacy or teaching real or authentic science, and this is seen in a widening number of documents. The National Standards established for teaching mathematics and science advocate that using inquiry as a cornerstone for effective instruction through the use of instructional technology will produce the following beneficial results:

- Mathematics and science become more meaningful, better understood, and hence more useful when applied in real-world applications of interest to students.

- The extent to which science is studied and understood is substantially increased with a significant economy of time when mathematics and science are linked through technology.
- The quality of learning and retention improves dramatically when activities are made meaningful and relevant through authentic science.
- Motivation increases dramatically when students investigate real-world situations and participate actively in the hands-on process.
- Student attitudes toward mathematics and science improve when students
  - (a) Feel ownership in the process of learning gained through the use of technology.
  - (b) Engage in hands-on tasks with reasonable assurance of success.
- Student understanding of mathematical and scientific concepts (with a focus on problem-solving strategies, reasoning, patterns, and relationships) will be enhanced by integrating technology.

The GLOBE Program fosters coordination among the multiple agencies responsible for science education, as evidenced by the funding and non-funding federal partners involved. These include the National Oceanographic and Atmospheric Administration (NOAA), the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), the United States Environmental Protection Agency (USEPA), and the Department of Education and State, as well as a variety of partners participating at the local level. Some $15 million per year in federal funds is invested in GLOBE—an investment that need not be duplicated on the local level for schools to be able to use the tools and infrastructure GLOBE has developed. Instead, funding at the local level can be used to train teachers and improve the quality of science education in K–12 schools.

The University of West Georgia, in collaboration with the Georgia Institute of Technology, developed a statewide initiative project known as *Georgia Goes Global!* The initiative was a partnership with the GLOBE Program. In the fall of 1999, the universities co-hosted a GLOBE teacher training session funded by an Eisenhower High Education Grant. The workshop trained 48 K–12 in-service science and mathematics teachers from 15 counties in Georgia and was conducted by faculty from both institutions. Each participant became a certified GLOBE teacher and their institution a designated GLOBE school. Participants were trained to implement the protocols for each learning activity utilizing the appropriate data collecting methodology, instrumentation, and reporting of data via the Internet.

In the fall of 1999, the universities co-hosted a GLOBE teacher training session funded by an Eisenhower High Education Grant. The workshop trained 48 K–12 in-service science and mathematics teachers from 15 counties in Georgia and was conducted by faculty from both institutions. Each participant became a certified GLOBE teacher and their institution a designated GLOBE school.

Project Goals and Objectives

The goals of the *Georgia Goes Global!* Initiative may serve as a model for implementation for the GLOBE Program. These goals are to

- Train teachers throughout Georgia to be GLOBE teachers.
- Mentor new and existing GLOBE teachers, helping to assure that they are successful in implementing the program.
- Build partnerships with school systems and with other higher education units in order to enhance our ability to meet the geographic and temporal constraints of teachers.

Implementing the GLOBE Program in schools achieved several objectives by

- Providing professional development opportunities for in-service teachers.
- Reaching thousands of school children and their families, helping them to understand the environment, the scientific process, and how computers and computer-based information resources function in our global society.
- Reinvigorating the curriculum in multiple disciplines by providing proven technology-based learning tools as well as research data on their use and impact.
- Improving students' test scores in mathematics and science.
- Encouraging students to pursue careers in science and technology.

Theoretical Framework

The GLOBE Program is grounded in the tenets of a constructivist learning environment. The students are the thespians and the whole world is their stage, providing the students with real-world experiences in scientific research. It is a learning environment that emphasizes the student as an active participant in the learning process, the importance of collaboration, and the need for authentic or meaningful contexts for problem-based learning.

A complex environmental problem or scenario in an authentic context that reflects the interests and abilities of the learners provides the "student-as-scientist" an opportunity to co-construct new knowledge in a collaborative format.

A complex environmental problem or scenario in an authentic context that reflects the interests and abilities of the learners provides the "student-as-scientist" an opportunity to co-construct new knowledge in a collaborative format. This helps to promote the science process as "true" inquiry-based and open-ended, rather than the traditional "cookbook" laboratory experiments with previously known answers. Prior knowledge built on experiences of the learner profoundly affects how the learner interprets new ideas and concepts to become an independent learner.

In the GLOBE Program, the students are engaged as active participants in the learning process, vis-à-vis meaningful dialogue with peers, instructors, and scientists. The student becomes a self-directed learner, and the role of the instructor becomes that of a facilitator. This student-centered approach empowers the student to communicate with the authority of a scientist as a part of a community of learners to move purposefully together toward an inclusive kind of "talking science" (Mintzes, Wandersee, & Novak, 1998).

The primary criterion for selecting a GLOBE environmental measurement is its potential benefit to the world science community in understanding the earth's environment (Finarelli, 1998). The GLOBE protocols should also have educational value as a scientific methodology and as an interdisciplinary approach embodied in the learning activities facilitated by the students' development of problem-solving and critical-thinking skills (Finarelli, 1998).

The GLOBE protocols encompass the areas of environmental study that focus on understanding the earth's systems as a whole, on the dynamics of environmental change, and on connecting that knowledge to societal needs (National Science and Technology Council, 2000). The protocols were developed by scientist/educator teams with a Scientist Principal Investigator and an Educator Co-Principal Investigator. The number of protocols continue to evolve; however, the areas of atmosphere/climate, hydrology, soils, global positioning (GPS)/remote sensing, and land cover/biology are the primary focus. This is consistent with the U.S. Global Change Research Program's interdisciplinary elements:

In the GLOBE Program, the students are engaged as active participants in the learning process, vis-à-vis meaningful dialogue with peers, instructors, and scientists.

- Understanding the earth's Climate System, with a focus on improving our understanding of the climate system as a whole.
- Biology and Biogeochemistry of Ecosystems, with a focus on improving understanding of the relationship between a changing biosphere and a changing climate and the impacts of global change on managed and natural ecosystems.
- Composition and Atmospheric Chemistry, with a focus on improving our understanding of the global impacts of natural and human processes on the atmosphere by determining the effect of such changes on air quality and human health.
- Paleoenvironment and Paleoclimate, with a focus on providing a quantitative understanding of the envelope of natural environmental variability.
- Human Dimensions of Global Change, with a focus on explaining how humans intervene in the earth system and are themselves affected by the interactions between natural and social processes.
- The Global Water Cycle, with a focus on improving our understanding of water availability and water quality (NSTC, 2000).

These protocols conducted by participants all over the world to monitor the global environment will produce data sets that have a broad geographical coverage that will serve as an invaluable contribution to understanding the earth's environment.

The GLOBE Program is one of the most beneficial curricula developed to effect reform in science education. The collaborative partnership between the University of West Georgia and the Georgia Institute of Technology as a statewide initiative has impacted innumerable students in school districts across the state. The implementation of the program has placed the concepts of authentic learning, student-scientist partnership, and inquiry-based pedagogy into a pragmatic context.

If we are to succeed in effecting reform in science education and fulfill the goals of Project 2061, science literacy for all Americans, we must develop curricula that provide the venue for students to become self-directed researchers and actively engaged in the learning process.

If we are to succeed in effecting reform in science education and fulfill the goals of Project 2061, science literacy for all Americans, we must develop curricula that provide the venue for students to become self-directed researchers and actively engaged in the learning process. We must also provide the professional development for in-service and pre-service teachers for implementing standards-based teaching and learning.

Subsequent chapters are written by in-service teachers who were participants in the GLOBE training program. Chapters two through six are first-hand accounts of a specific protocol implemented in their respective educational settings. Each chapter was also co-authored by a science educator or scientist in their respective field or discipline. In some cases, the accounts include how the GLOBE training acted as scaffolding for extending or developing related projects or course offerings.

The concluding chapter summarizes the impact of the GLOBE Program:

- Illustrating how teachers and students learned to understand science and appreciate what it means to be a scientist
- Acquiring life skills such as observing their world
- Understanding the importance of accuracy, consistency, and persistence
- Acquiring and managing responsibility
- Appreciating how the world's climates and cultures interconnect

This chapter will also make note of how GLOBE engages all students, regardless of modality preference, learning style, ethnicity, race, culture, learning disability, or special need. The international nature of GLOBE adds the potential for social science, foreign language, and cross-cultural dimensions to the program. GLOBE students communicate (usually over the Internet) to conduct joint research, but also to learn more about each other's countries, languages, and cultures.

A scientifically informed citizenry is a prerequisite for effective functioning of a democratic society in an era dominated by scientific and technological advancement. To quote Frederick Antczak (1985):

> *In democracy, the people rule—that is, they rule insofar as they make their own decisions. Life in an increasingly technologized society imposes increasing demands on society's decision makers. If, in such an era, democracy's decisions are to be made intelligently and effectively, the public must somehow be reconstituted intellectually.*

The alternative would be to abandon the fight and admit defeat. However, the authors concur with Isaac Asimov, who stated, "Never! As for myself, I may be defeated at last, but I intend to struggle to the end. I will not surrender, embrace ignorance, and kiss its hideous face" (Asimov, 1983).

References

American Association for the Advancement of Science (1993). *Benchmarks for science literacy.* New York: Oxford University Press.

Baker, T. R. (December 2001). Success with GPS. *The Science Teacher. 68*(9), 38–41.

Damian, C. (2001). It's about relevancy. *Eisenhower National Clearing House Focus, 8*(3), 25.

Finarelli, M. G. (1998). GLOBE: A worldwide environmental science and education partnership. *Journal of Science Education and Technology, 7*(1), 77-84.

Goldfarb, T. D. (2001). *Taking Sides* (9th ed.). Guilford, CT: McGraw-Hill/Dushkin.

Gore, A. (1993). *earth in the balance: Ecology and the human spirit.* New York, NY: Plume.

Lemke, J. (1990). *Talking science: Language, learning and values.* New Jersey: Ablex Publishing Co.

Marlowe, B. A., & Page, M. L. (1998). *Creating and sustaining the constructivist classroom.* Thousand Oaks, CA: Corwin Press, Inc.

Martin, B., Kass, H., & Brouwer, W. (1990). Authentic science: A diversity of meanings. *Science Education, 74*(5), 541–554.

Mintzes, J. J., Wandersee, J. H., & Novak, J. D. (1998). *Teaching science for understanding: A human constructivist view.* New York, NY: Academic Press.

National Science and Technology Council (2000). *Our changing planet.* Washington, DC: Office of Science and Technology Policy.

Nelson, G. D. (2001). *Project 2061 update 2001–2002.* Washington, DC: American Association for the Advancement of Science.

Ridgway, J. (2001). Debating the science curriculum of the future. *Eisenhower National Clearing House Focus, 8*(4), 18–22.

Rubin, C. S., & Wilson, S. (October, 2001). Inquiry by design. *The Science Teacher, 68*(7), 38–43.

Sutman, F. X. (2001). Mathematics and science literacy for all Americans. *Eisenhower National Clearing House Focus, 8*(3), 20–23.

Windschitl, M. (June 1999). The challenges of sustaining a constructivist classroom culture. *Phi Delta Kappa,* 751–755.

Wright, A. W. (October 2001). The ABCs of assessment. *The Science Teacher, 68*(7), 60–64.

Zinn, B., Grut, S., & Kafkafi. (Winter 1999). First-rate crops from second-rate water. *Science Activities, 35*(4), 27.

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Chapter Two
If the Sky Were Falling, We Would Know It!

By Rhonda Baldwin, Ed.S., with Gail Marshall, Ed.D.

Sharing the GLOBE Program with my students has been a personal and professional pleasure. When my students enjoy learning, I feel wonderful! Every student who participates in the GLOBE Program learns.

In the fall of 1999, Fairplay Middle School went GLOBAL! The Douglas County School System gave teachers from each school an opportunity to attend a training session at the State University of West Georgia. I was eager to take advantage of the opportunity and explore what the GLOBE Program had to offer my students and our school. The training sessions were spread out over four days: two in September and two in November.

I arrived for our first training session with much anticipation. We were given our GLOBE Program teacher manuals and became familiar with the organization of our materials. We made several instruments that would be used throughout the training session to collect data, and we were introduced to the GLOBE protocols. I was very impressed with the protocols and realized how this would stress constants in an experiment for students—authentic science at its best!

I was very impressed with the protocols and realized how this would stress constants in an experiment for students—authentic science at its best!

We looked over the GLOBE learning activities that are designed to help students understand concepts of the program. The activities teach concepts and protocols, which are followed within a constructivist learning environment. We worked in cooperative groups and did several of the activities in the training session. Each of us commented on the value of the activities with regard to the state curriculum objectives in science.

Wow, What an Informative First Day!

On our second day of training, we covered GPS/remote sensing, hydrology, soil, and land cover/biology protocols. We also were introduced to the GLOBE website and began learning how to send data collected by the website. We had a very productive, learning-filled day, and I looked forward to sharing what I had learned with my students. Although I would not be certified by GLOBE until I completed my training in November, I could not wait to get started. We were studying light waves in my class at that time, and I used the remote sensing video as enrichment to our unit. I explained what I knew about the GLOBE Program and asked my students if they would like to participate. I know my enthusiasm had a strong impact because every class got excited, too!

We needed some materials for data collection, and we needed to learn the protocols. My students and I decided to seek help from our community. I drafted a letter to parents detailing what we wanted to do and how the activities would help us meet our learning objectives. I also drafted a letter, which the students showed to community businesses, to request financial support in purchasing the materials we needed. We did not want to take a long time to try to collect our money, so we set a one-week collection goal. I knew we could make several of the instruments we would use; however, the students wanted to purchase laboratory-quality materials. I let the students participate, as they felt comfortable. We began establishing our GLOBE groups for training during that week period also. I found my students working together to reach our goals, financially and academically. They checked with each other daily about the money donated, and they discussed the protocols in class and after school in their neighborhoods and on the phone. This added to my excitement. We were working together, and I knew they would enjoy our GLOBE experience.

I found my students working together to reach our goals, financially and academically.

At the end of that whirlwind week, we had raised enough money to purchase all of the materials needed to participate in the GLOBE protocols. This led to the most difficult part of our experience: waiting for the materials to arrive. I called the recommended distributor on Friday afternoon at the end of our fundraising week and placed our order with a request for a "rush" order. The distributor was very cooperative, and we had most of our materials within two weeks; however, our instrument shelter was on back order, and we needed it to begin our atmosphere protocols.

One of my students stayed after class one day and asked me about the shelter. She had seen the one being used on the GLOBE introduction video. I gave her the plans in the teacher's manual on a Friday, and she took them home to show her grandfather. Monday morning, we had our instrument shelter built to perfection. I was so proud that this young lady thought of her grandfather and his woodworking skills. I sent a thank you note that same day to her grandfather. The following week, I received a note from the young lady's mother, who thanked me for providing her daughter with an activity where she shared knowledge and time with her grandfather. I began to realize how much our activities impacted our community and parents. I had parents ask me at football games and school events about our experiments. I was proud to share our progress and let them know that we could not have participated without their financial and motivational support.

By November, the students were looking forward to when I finished because they knew our data collection would officially begin. I chose to implement the GLOBE atmosphere protocols first. Data is collected daily, and the protocols only take about 10–15 minutes. The students agreed that the atmosphere protocols were the best to begin with, so that's what we did. Even though we were concentrating on the atmosphere, we continued studying and reviewing the other protocols.

Atmosphere Protocols: "A Day of Data Collection"

When students go outside to collect atmospheric data, they first record the Universal Time for data collection that day; data is always collected close to Solar Noon. Then they follow the cloud cover and cloud type protocols. Students use a cloud chart to identify the type of clouds in the sky, and they use their learned knowledge to determine the amount of cloud cover. Students then look at the rain gauge and determine the amount of rainfall since the previous data collection and record their findings following the solid precipitation protocol. If rain was collected in the gauge, the students use a pH pen to determine the pH level of the rain collected and empty the gauge for the next rainfall collection. Students then read the thermometer and identify the maximum, minimum, and current temperatures (following the correct protocol when collecting this data); then, they reset the thermometer for the next day's data collection.

The daily data collection is a group effort. Students work in small groups of two to three people. This helps confirm the accuracy of data collected. Students find groups are most useful with cloud identification and cloud coverage identification.

Once the data is collected, students bring in their notes and send in their data to the GLOBE network. Students enjoy collecting the data; however, they also enjoy the data entry. The network is easy to maneuver through, and helpful hints and reminders are always given when data is posted. Once students have entered their data a few times, they become experts with the program!

Fairplay Goes GLOBAL

During our first year of participation, I had so many students who were excited about participating. I know this is directly linked to their ownership of the implementation of the program. Each student participated in data collection.

When students go outside to collect atmospheric data, they first record the Universal Time for data collection that day; data is always collected close to Solar Noon.

We participated in the GLOBE Learning Activities to prepare us for data collection. We learned how to observe, describe, and identify cloud types with *Observing, Describing, and Identifying Clouds*; we learned how to estimate cloud cover with *Estimating Cloud Cover: A Simulation*. I always start my class with a short science warm-up, and observing clouds was perfect for this one. Students immediately went outside at the beginning of class and made cloud observations with their group. My classes function in learning groups on a daily basis, which is ideal for GLOBE activities. They took three to four minutes for observation and came back into class to record their group findings. This was an excellent protocol-training process. We compared our observations and fine-tuned our understanding of the cloud type and cloud cover protocols.

Training on the instrument shelter was fun. One group from each of my five classes volunteered to help determine the best location for our shelter based on protocols. These groups met after school one day to discuss their findings and agree on the best site. In my situation, the best site happened to be right in between our two practice football fields; however, I was concerned that the coach would not allow us to place the shelter where we wanted. Several of the students who helped determine the best location were on the football team, and they volunteered to talk with the coach about what we wanted to do.

The daily data collection is a group effort. Students work in small groups of two to three people. This helps confirm the accuracy of data collected.

The coach approached me the next day smiling. He was so impressed with the way our request was presented by his football players that he agreed to let us put up our shelter. He explained that the boys had taken him out with the measuring tape and clinometer to explain why we had to put our shelter in the middle of his two fields. I was concerned about whether other players and students might knock the shelter accidentally; however, my students and the coach assured me this was not a concern, and it hasn't been yet! The students have ownership of our materials, and they take care of them.

After the instrument shelter was in place, we learned how to collect data for temperature and rainfall. I would send each group out of class for about five minutes to collect their data; at the end of the class, we would compare our data and continue our fine-tuning. *The Land, Water, and Air Learning Activity* was also used to help us understand our instrument shelter. We discussed and reviewed the *Solid Precipitation Protocols,* and the students joked about the slim-to-none chances of observing snow worth measuring in Georgia; needless to say, we did not purchase a snowboard. We did receive some snow over the winter holidays that first year, and some of the die-hard GLOBE students wanted to send in some of the observations they had made at home about snow accumulation. We did not record the information in the data bank because the data was not collected at school with the correct protocols; however, we did note our information at the end of a report upon our return from the break.

The coach approached me the next day smiling. He was so impressed with the way our request was presented by his football players that he agreed to let us put up our shelter. He explained that the boys had taken him out with the measuring tape and clinometer to explain why we had to put our shelter in the middle of his two fields.

Authentic science best describes the incorporation of this program. In Georgia, we follow a *Quality Core Curriculum*. Several curriculum topics are explored through GLOBE. Students use the Scientific Inquiry Process as they collect and review all of the data for the specific GLOBE protocols; standards of measurement are a daily part of our atmosphere investigation. I have always tried to improve our understanding of standards of measurement. The GLOBE protocols are excellent in helping students with this concept. I smile because I watch my students measure and record data accurately without even thinking about it. I know this is much better than handouts, discussions, and in-class experiments. As we collect rain and determine the pH level, students question any variation, and we discuss the possible impact of humans on the rain pH level. Weather phenomena become real to the students; they are more attentive to changes in the weather around them, and they have a better understanding of weather forecasting as they collect data over several weeks.

My first-year GLOBE students matured and went on to high school. Watching them go, I knew the GLOBE program experience would make a difference in their future endeavors. As I greeted my 2000–2001 students, I began discussing GLOBE with my classes. They did not have the excitement we experienced our first year; however, several of my students had heard about what the previous class had been doing, and they were eager to participate. We are still GLOBEing and reaping the benefits of its learning power. My students often give up lunchtime to collect data and will even send the data to GLOBE from their home when our system is down at school.

My students often give up lunchtime to collect data and will even send the data to GLOBE from their home when our system is down at school.

I asked several of my second-year GLOBE students to write about their GLOBE experiences. The following are excerpts from the students' essays in original text:

My GLOBE Experience

By Ryan Anderson

I like GLOBE. It has been an interesting experience for me. I have learned a lot. I believe my experience in GLOBE could help me in future weather experiences.

Our teacher told us what to do. After a while, she put us in groups and alternated my classmates and me. On the days we went out and collected our data, we would use a GPS system and find the Universal Time. Then we would go out to the Instrument Shelter and determine the maximum, minimum, and current temperature of that day. If it rained one day, the people that collected data for that day would get the water and then test the water with a pH pen.

My eighth-grade class did a science project. I found my topic to be a lot easier since I was a part of GLOBE. For my project, I found the silt level and pH of one of my friend's creek. I used a turbidity tube to find the silt level, then a pool pH tester to test the water for pH.

GLOBE was really fun, and I learned a lot. I would recommend anyone to join GLOBE.

My GLOBE Experience

By Greg Mitchell

I think that the GLOBE Program is a very good program. I like studying about the atmosphere. Learning about the clouds is neat. I learned how to use a GPS unit.

The rain gauge holds water, and when we go out to take the measurements (data), we measure it in millimeters. Then we take it in and we test the pH level of the water. We use a pH pen. I like to study water.

Earlier in the year, I did a project on the pH and the silt of the creek in front of my house. I took data every other day. I did this for a month or two and then made a project board to enter into the science fair.

I hope they have something like this in high school because it puts you ahead in class. It helps you understand everything we do in class as well. I think everyone needs to be in the GLOBE Program.

My GLOBE Experience

By Christina Morgan

I enjoy GLOBE. It has been fun. I would get out of lunch about halfway through twice a week and go outside. We collected data on cloud cover, cloud type, temperature, and rain amounts. If it had rained, we would go inside and test the rain for the pH level; I liked it when it rained. I even liked going out into the rain to collect data.

After collecting the data, we would put all of our information in the computer and send it to GLOBE. I liked learning the cloud types. What we learned will probably be good to know for science classes in the future.

My GLOBE Experience

By David Whitehead

The GLOBE Program is a great thing to get into if you like studying the atmosphere. I am in eighth grade and most people in the eighth grade know how to read a rain gauge; I did not start learning to read one until I got in the program. I also learned how to use the pH pen; I did not even know what it was until I got involved with the program. The program teaches you how to read instruments and take measurements.

I had a science project I had to do, and I could pick the topic. Well, I chose to do mine on clouds because in the GLOBE Program I had been studying the clouds and keeping data on the clouds. This made my project easy to do, and I already had data on the clouds so I finished my project a week before it was due. The GLOBE Program puts you ahead of the class, because the stuff you do in the program helps you understand it better than when the teacher teaches it in class.

Chart 1

Data Collected: May 11, 2001
School Name: Fairplay Middle School
Observer Names: Christina Morgan and David Whitehead

Universal Time	Cloud Type	Cloud Cover	Rainfall	Current Air Temp	Maximum Air Temp	Minimum Air Temp
16:40	Stratus/ Cirrocumulus	Broken	*	38 C	48 C	4 C

* No rainfall had occurred; thus, no pH-level reading was necessary.

My GLOBE Experience

By Jordan Phillips

I believe all eighth-grade students should get into the program because it teaches a lot, and it is a fun activity.

Now, I don’t know about the others, but for me it has been an exciting and hardworking experience. At first, I wasn’t sure what I was expected to do in the program, but it is fun to go and find out what is going on in the world outside us. Also, I have enjoyed learning about the environment outside of work and school. While in GLOBE, although being fun, I have had to work hard, along with my other classmates, to give the correct observations. After I finish in the GLOBE Program at Fairplay, I am hoping to again start studying the environment later in my school career. This GLOBE Program has really broadened my outlook on the world.

Demographic Information

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Chapter Three
If I Were a Fish, Would I Swim Here?

By Staci Nash, M.Ed., with Rebecca Dodge, Ph.D.

> *The value of GLOBE for a diverse set of subjects is its flexibility and adaptability for multiple skill levels and subjects.*

The GLOBE hydrology protocols focus on water quality as it affects the environment. Water quality measurements made by GLOBE teachers and students include transparency, water temperature, dissolved oxygen, pH, electrical conductivity, salinity, alkalinity, and nitrate. These measurements can be incorporated into classes, laboratories, and field trips in multiple subjects because water quality has physical, biological, and sociological impacts. For example, performance of the chemical water testing requires an understanding of chemical reactions and how temperature affects such reactions (chemistry focus). Water transparency, especially changes in transparency following rainfall events, is related to soil type (earth science focus) and to land cover (biology focus). Clearly, water quality affects human society in a myriad of ways (sociology/geography focus).

All of the parameters measured for GLOBE hydrology protocols can strongly affect organisms living in and around water.

Hydrology Protocols

All of the parameters measured for GLOBE hydrology protocols can strongly affect organisms living in and around water. Transparency is a measure of penetration of sunlight into water. Since sunlight provides energy for photosynthesis, its presence or absence controls how effectively plants can grow by taking up nutrients and how effectively they can give off oxygen. Transparency decreases as turbidity increases, usually because of suspended sediments or pollutants from sources such as sewage treatment plants, agriculture, development, and logging. Light penetration depths control the depth to which algae and other plants grow. These plants are the foundation for the food chain, including microorganisms, fish, amphibians, and water birds.

Water temperature can be adversely impacted by development, as when trees are cut and shade is lost.

Water temperature strongly affects the amount and diversity of life forms that can live in a body of water. Water temperature—and, therefore, living organisms—typically change as the seasons change. Water temperature can be adversely impacted by development, as when trees are cut and shade is lost. Industrial processes can produce warm water that, when released into the natural environment, can cause adverse effects on both plants and animals. Dissolved oxygen content is also critical for aquatic animals, and warm water holds less oxygen. Decaying organic matter also consumes oxygen and is often increased when sewage treatment plants put effluent into water bodies. This reduces

dissolved oxygen, often to critical or fatal levels. Sewage discharges can also affect nitrate levels in water bodies. Some nitrate is critical for plant growth, but an excess amount associated with sewer discharge can cause excess plant growth that adversely impacts fish and other aquatic animals.

When investigating the water quality of a lake or a pond, the inter-connectedness of the hydrology protocols emphasizes the systemic nature of the watershed.

As a measure of the acid content of water, pH strongly controls aquatic plants and animals because they are usually sensitive to low or acidic pH levels. Air pollution can increase the pH of rainfall and, consequently, increase the pH of runoff into streams. Alkalinity is a measure of a water body's resistance to such change when acidic runoff or pollution is added. Alkalinity at appropriate levels can protect aquatic organisms. Electrical conductivity is a measure of dissolved impurities in a water body. Such impurities adversely influence plant and animal growth and make water unsuitable for domestic and agricultural use as well. Salinity, or salt content of water, determines the type of plants and animals able to live in water bodies. Water with high levels of salinity is unsuitable for domestic, agricultural, and industrial uses.

When investigating the water quality of a lake or a pond, the interconnectedness of the hydrology protocols emphasizes the systemic nature of the watershed. These variables have a strong effect on plants and animals, making the hydrology protocols fit quite well into the high school biology classroom.

GLOBE in the High School Biology Classroom

I have been a high school biology teacher for seven years, and I am a firm believer that children learn through many different avenues (visual, auditory, etc.). Although I vary instruction to include all learning styles, I believe the most successful mode of instruction, the one enabling the most students to grasp the information, is hands-on activities—whether a student experiment, the building of a model, or even role playing.

During the fall, I teach a unit on ecology. We spend a great deal of time outside observing and manipulating nature. One of the major concepts covered in ecology is the result abiotic factors of an environment—such as temperature, gas content, and pH—have on biotic factors, such as the plants, animals, and protozoa. The unit culminates with a half-day field trip to a medium-sized pond within walking distance of our campus. For years, I have searched for lab instructions that included not only the chemical tests, like pH and dissolved oxygen, discussed in class but also the collecting of live specimens and a comparison of those specimens present to the quality of the environment. In the past I have taken many different laboratory exercises from many different sources and created a series of test procedures. The students were also given written instructions to observe certain features of the area, such as slope, sun versus shade, and turbidity, as well as collect animal, plant, and protozoan specimens from the area. The preparation for the field trip was quite cumbersome. Procedures from many different sources are not only at times confusing for the students but also require numerous and varied pieces of equipment, chemicals, and paperwork.

I was most interested in the hydrology portion of the course. I was delighted to see the same tests I performed with my classes on the pond study field trip, but in clear, concise packages of information.

In the summer of 2001, I took a GLOBE course as part of my master's degree at the University of West Georgia under Professor Rebecca Dodge. The course was intended to certify the participants as GLOBE teachers and enable them to involve their classes in the collection of GLOBE data. We discussed soil protocols, hydrology protocols, etc., as well as investigating the different aspects and information available on the GLOBE website. I was most interested in the hydrology portion of the course. I was delighted to see the same tests I performed with my classes on the pond study field trip, but in clear, concise packages of information. For example, in the past, in order to determine the turbidity of the water, my class captured a sample of water in a clear glass container and judged the sample as cloudy, clear, etc. The results from this method were as varied as the students themselves because it requires a judgment call. GLOBE suggests the use of a turbidity tube or Seechi disc, which enables the students to conclude a definite measurement value for turbidity. Each hydrology test is accompanied by a short set of instructions, a data worksheet, an instructional video, and even laboratory exercises to be performed in the classroom to give the students background knowledge. For example, the GLOBE Program provides an exercise to test the pH of household products to be performed in the classroom prior to entering the field, giving the students a reference point in which they can compare their pond water readings. Instead of drawing the sun vs. shade, I could now simply give my students the cloud cover chart for comparison. The GLOBE Program also provides a set of procedures for collecting living specimens. The GLOBE kit contains illustrations for comparison and identification and explanations of the water quality of an area according to the specimens captured.

The Perfection of the GLOBE Protocol

I began by introducing my students to the basic purpose of the GLOBE Program. I discussed its use worldwide and the different areas from which schools collect data. I then explained that we would be using only the hydrology protocols. The protocols that we performed at the pond were transparency, water temperature, dissolved oxygen, pH, conductivity, and alkalinity. The students also used the appropriate protocols to collect living specimens. After reviewing the protocols with the students, viewing the instructional video, and calibrating the appropriate equipment, the students were prepared for the field study.

I decided to allow only one of my five biology classes to use the GLOBE protocols. I was interested in comparing the two groups to determine which group of students remained on task, worked independently, and accomplished the most. The class using the GLOBE protocol worked the entire four hours virtually without my help. The protocols prepared by GLOBE are so detailed and specific that the students had little if any questions or difficulties.

The class was separated into four groups of five students each. The groups had to compile their data at the end of the day and come up with averages for the pond (an average pH, an average dissolved oxygen, etc.). The next day in class we discussed the data. If one group's dissolved oxygen reading, for example, seemed much different compared to the others, we discussed reasons for this, such as the temperature or time of day in which they conducted the test. We discussed the impact each one of our readings has on the body of water. For example, a high water temperature lowers the oxygen levels and detrimentally affects the flora and fauna. We determined that our body of water actually had healthy readings, and this was supported by the varied and abundant amounts of life we found around the pond.

We determined that our body of water actually had healthy readings, and this was supported by the varied and abundant amounts of life we found around the pond.

Overall, using the GLOBE protocols yielded much better results than any previous procedures I have ever used. Not only did GLOBE decrease my workload, but also the students seemed to understand more of the concepts I was trying to convey.

Demographic Information

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Chapter Four
Exceptional Environmental Scientists

By Carla Pollard, Ed.S., with Terrie Kielborn, Ph.D.

> *I think that the most important aspect of this class is the interest level it generates for students. They love to come to this class and can't wait to go outside to study or work in the laboratory. They even generate questions about their environment and develop ways to get the answers. Students that do not necessarily excel in other classes can take the lead in their groups and be the expert. Attendance levels are up, and discipline problems are down.*

GLOBE Beginnings

When I first learned of the GLOBE training at West Georgia, I was not really interested because my concentration areas in teaching are mainly chemistry and math, and this training sounded more like biology. But I thought that I might be able to apply some of the hands-on laboratory activities in my chemistry classes. I knew that some of the people I had attended graduate classes with were planning to attend, so I thought that we might be able to collaborate in some science experiences in our area.

I found the trainers to be very knowledgeable and enthusiastic about implementation of the GLOBE protocols. They answered questions in detail and offered many ways to adapt lessons to fit into our curriculum. I learned that I did not have to totally restructure my teaching and discovered that by including GLOBE protocols in regular instruction, my curriculum would be enhanced.

To learn all of the GLOBE procedures, we worked in groups and actually conducted the protocols in the field. Learning to properly use the equipment was a high priority, and as a final learning experience, each group presented a class activity to show the ease of application of the areas included in GLOBE. Working in the field to learn about the local environment was not only fun but also interesting in that I learned more about the area in which I had grown up and attended college.

Implementing GLOBE through an Environmental Science Course

After completing the GLOBE training, I was asked to teach the GLOBE protocols as a separate class to be taught at my school rather than partially implemented in one subject area. Fortunately, my school was in the process of changing to the 4x4 block schedule, enabling students to take more classes during the year. As the science department chairperson, GLOBE seemed like a "natural" selection for a new science elective to offer our students. Since the length of a block class is 90 minutes, there was ample time for completion of the activity, discussion of labs, and going outside. My administrators could sense how much I had enjoyed the GLOBE training, and we discussed the possibility of offering an environmental science class using the GLOBE protocols as the basis for instruction.

Many of the protocols for GLOBE require specific equipment for implementation. My assistant superintendent approached me about a PT3 grant available for purchase of scientific supplies. As it turned out, the amount of the grant was just enough to cover the cost of most of the equipment needed to implement the four main GLOBE protocols. The PT3 grant required a partner at the university for the grant, so I contacted Dr. Terrie Kielborn, a professor of science education that I had met during GLOBE training at UWG. She agreed to partner our school and work with me in the implementation of GLOBE protocols through an environmental science class.

With my background in math and chemistry and my training in GLOBE protocols, I still felt somewhat deficient in my skills in the environmental science area. In the summer of 2000, the geology department of UWG offered a class involving field study of the Buffalo Creek Watershed. I took this class to help me incorporate environmental issues that would be specific to the West Georgia area.

Our Collaboration

In the fall of 2000, 20 students in grades 9–12 signed up for this new environmental science course. My administration was very supportive of the "outdoor" nature of the class. The students enjoyed the mixture of learning both in and out of the classroom, especially at the secondary level.

My administration was very supportive of the "outdoor" nature of the class. The students enjoyed the mixture of learning both in and out of the classroom, especially at the secondary level.

Student comments included the following:

- One of the things I enjoy most about this class is going outside. I love exploring the nature of the campus and all of the possibilities we have to experiment on.
- I seem to learn more, and I know I enjoy working outside of the classroom.
- I have always been one to like the outdoors, and we spend about 50% of our time outside.
- This class is a lot more fun because we go outside almost as much as physical education does.

The Alabama Department of Education (1996) considers the classroom "any place where scientific inquiry is occurring, whether that is a classroom, beach, park, or museum" (p. 7). Activities were conducted inside to learn the GLOBE protocols before going outside to practice and later to implement.

The students scoped out the campus to choose sites for our atmosphere station, land cover area, soil study area, and hydrology study. Our school had an outdoor classroom that made a great land cover and soil site, while a stream just a few hundred feet down the road, made the perfect hydrology site.

We decided that one of the best ways to understand our area was to collect articles from local newspapers related to environmental issues. Each student brought in an article each week for discussion. The class generated a current event book of environmental issues, and students kept summaries in their notebooks so we could concentrate on the main problems in our area. Students commented:

- I like when we discuss newspaper articles. We all get a say in what we think is wrong or right.
- I like doing the articles. It helps to keep everyone up-to-date about the news and the environment. Most teenagers do not watch the news, so it helps keep everyone informed.
- Since people have been bringing in articles and explaining them to the class, I have learned a lot about what is going on in the environment.

With my still-limited background in biology, I appreciated Dr. Kielborn's frequent visits to Bremen to help us with background information for conducting our tests. Another professor from UWG, Dr. Rebecca Dodge, accompanied her one day, and the students received a lesson on remote sensing. The students learned to use computers and the image of the Bremen area to understand land use and types of land cover in our immediate area.

We learned that clear-cutting of pine trees has had a major impact on our local land as well as the Tallapoosa River.

Dr. Kielborn also provided resources for our class. She loaned us posters of cloud types, tree identification books, water test kits, compasses, a sling psychrometer, and even gave us a hygrometer for our atmosphere station to report relative humidity. She helped to supervise and answer questions for students when we worked in the laboratory after collecting soil and water samples. She even walked through our outdoor classroom area with us and helped us identify trees and ground cover.

New Learning Experiences

Community resources can be obtained through other avenues. Our Haralson County Extension agency gave me the name of a resident expert on local environmental issues. Bud Jones, an author, taxidermist, and local environmental expert, runs a taxidermy service and owns and operates a local wildlife museum. Arrangements were made for my students to take a field trip to tour the museum and meet Mr. Jones. Dr. Kielborn joined us for the tour and lecture on Haralson County. We learned that clear-cutting of pine trees has had a major impact on our local land as well as the Tallapoosa River. We also learned about the different types of animals native to our area and the impact of changes in our area to their habitat. The students were able to ask questions and see local wildlife displays in the museum.

Dr. Kielborn arranged a different learning experience for us. Our environmental science class made a trip to Bay Springs Middle School, where they shared what they had learned about soil studies to two classes of sixth-graders. Using some of the instruments, such as augers, soil thermometers, and infiltration rings, the high school students conducted the GLOBE soil protocols with the younger students. The UWG geology department loaned an extra auger so that the sixth-graders could learn about their school's soil through a hands-on approach. The sixth-graders rotated through various stations on soil studies, each set up and taught by a team of high school students. The high school students worked patiently with the younger students, explaining the purpose of each soil test and what the results of these tests tell us about soil. It was a very positive experience for both the high school and middle school students. The sixth-graders learned about soil, while the high school students shared information and procedures that they had previously learned through the environmental science class. Students commented:

The high school students worked patiently with the younger students, explaining the purpose of each soil test and what the results of these tests tell us about soil.

- I feel that I helped the children in my soil characterization group have fun and learn a little about soil.
- The kids, I think, were surprised to see how much of a difference there was in each layer.

The middle school students were impressed by the knowledge and presentations by the high school students. One sixth-grade girl commented that she hoped she would be in a science class that would work with younger students. These high school students had the rare opportunity to share what they had learned with others.

> *Involvement in learning, involvement with other students, and involvement with faculty are factors that make an overwhelming difference in student retention and success in college. By its very nature, collaborative learning is socially and intellectually involving. (Smith & MacGregor, 1992, p.11)*

Studying Soil Is Challenging Yet Fun

The soil protocol is probably the most difficult of the four GLOBE areas but the most enjoyable for students once they are comfortable with the procedures. Another professor at the university, who is also a GLOBE trainer, said that many schools elect to avoid the soil protocols because they are much more challenging and difficult to conduct. Our soil study began by conducting the field measurements protocol on an exposed bank near an unpaved road near our out-

The soil protocol is probably the most difficult of the four GLOBE areas but the most enjoyable for students once they are comfortable with the procedures.

door classroom. Each group had a copy of the field measurements protocol from the GLOBE notebook in hand. First, we exposed the soil by removing an outer layer of dried soil from the surface. We then used our color chart to identify as many colors as we could in the area. We learned quickly that having the soil charts laminated was a worthy investment because holding the moist soil next to the color charts was messy.

Each group took a sample and began to determine the structure of the soil (blocky, columnar, granular, platy, or prismatic). Most of our soil was granular in this area. Wearing plastic gloves, each student then took a sample of soil and studied its consistency, classifying each as loose, friable, firm, or extremely firm. We then wet the soil to form a ribbon in order to classify it as clay, clay loam, or loam. Working the soil between the fingers helped the students identify whether the soil contained silt or sand. We looked for the presence of roots and rocks and then tested for carbonates by squirting vinegar from a spray bottle and observing bubbling action.

Once we had completed this practice, students were more comfortable with soil classification and were ready to perform the protocol in our soil-testing area in the outdoor classroom. We chose an area near a platform so that we could sit down and also have a flat surface on which to lay out the soil for analysis. We used a plastic picnic tablecloth to lay out the soil, and students took turns using the auger and measuring the depth of the hole we were digging. The soil was laid out on the tablecloth as the auger was removed from the hole. Working as one large group, the students were able to lay out one meter of soil on the plastic, representing each level or soil horizon. The students used golf tees to separate the horizons that were visible by a distinct color and texture. Each group was assigned one of the six horizons and collected two samples of soil in soil cans for their horizon. Then the students conducted the field measurements protocol using their horizon sample.

Once we returned to the lab, the students weighed their soil cans and placed them in an incubator (our lab oven did not work) to dry. Each group then reported their field measurement results to the class for comparison. This allowed each group to practice following the protocol procedures yet learn about the results from others.

The students then began conducting the lab analysis and soil moisture protocols once the soil had dried. Each group weighed their dry soil and then used a sieve and a mortar and pestle to prepare the soil for testing. Using copies of the lab analysis and soil moisture protocols, they conducted the following tests on the soil from their horizon:

- Soil moisture
- Bulk density
- Particle size distribution
- pH
- Soil fertility (NPK)

GLOBE provides step-by-step instructions for each of the protocols through a teacher's edition, as well as online (*www.globe.gov*). The high school students were able to work independently on their tests using the printed version for each of these protocols. Dr. Kielborn was instrumental in helping students with testing techniques. We had some initial difficulty with the particle size distribution test because we only had two 1000 milliliter graduated cylinders. We had to share these, and then upon completing the calculations, we found that our results were incorrect. Once I ordered 500 milliliter graduated cylinders, we were later able to repeat the tests with better results. We found the learning activity "Making Sense of the Particle Size Distribution Measurements" to be very helpful in making the somewhat difficult calculations.

One student commented, "In all my other classes, all I do is sit and listen to a teacher lecture. But in Environmental Science, I get to do things and learn by hands-on experience."

The students really enjoyed working in the lab. One student commented, "In all my other classes, all I do is sit and listen to a teacher lecture. But in Environmental Science, I get to do things and learn by hands-on experience." The students showed initiative as they worked with soil that they had collected, as each group worked at their own pace. They shared equipment and helped each other with techniques as they mastered them. As the groups reported results to each other in the classroom, discussions were sparked by the differences in data that were found.

As the groups reported results to each other in the classroom, discussions were sparked by the differences in data that were found.

The infiltration protocol for determining the rate at which water soaks into the ground was difficult for us. The ground was very hard due to the drought we were experiencing, and we had trouble getting the infiltration rings far enough into the ground to prevent seepage. We also had some trouble getting the soil thermometer very far into the ground to test the temperature. The drought remains a major problem for our area as well as our state. However, we were able to go outside more often as we experienced more clear weather.

Anytime something is done for the first time, there is room for improvement. Most of the improvement is in the level of teacher confidence and knowledge of the "little" things that seem to make activities run smoother the second time around. The students were very complimentary of the course:

- I have always liked science, and now I really get to see what I have learned to do through experiments.

The success of this environmental course is deeply indebted to GLOBE, with its hands-on learning activities, real-life application, and integration of other disciplines, including technology.

- I have never liked science much before, but this class has changed the way that I feel about science.
- Classes like this are what make school even more fun. I look forward to going to this class every day when I wake up.
- The thing that would make this class better would be going outside every day, a couple of shovels, and enough compasses for everyone so that everyone can learn to use one.

Environmental Science Course, Part II

We had no trouble recruiting students to sign up for the following year's environmental science course. In fact, one student from the first class volunteered to be an assistant for the second year. He has proven instrumental in teaching protocols to the class and in entering protocol data onto the website. From a teaching perspective, it allowed the course to begin with the knowledge and expertise from the past year and with a higher degree of confidence. The success of this environmental course is deeply indebted to GLOBE, with its hands-on learning activities, real-life application, and integration of other disciplines, including technology. Because this class was offered to 9–12 grade level students, a wide range of interests and abilities were accessible. This was beneficial to the students because they learned to help one other, as well as how to work with each other. They were also able to capitalize upon each other's strengths. Some of the protocols, especially in soils, required quite a large percentage of mathematical ability, while other protocols were easier if the student had some background in chemistry or a laboratory science class. Overall, this experience allowed a group of students to not only learn about their local environment or about various laboratory procedures, but it also provided the conditions to learn them as real scientists.

Overall, this experience allowed a group of students to not only learn about their local environment or about various laboratory procedures, but it also provided the conditions to learn them as real scientists.

References

Alabama Department of Education (1996). The Alabama Course of Study: Science. Montgomery, AL.

GLOBE (Global Learning and Observations to Benefit the Environment), *www.globe.gov*.

Smith, B. L., & MacGregor, J. T. (1992). What is collaborative learning? In A. S. Goodsell, M. R. Maher, V. Tinto, B. L. Smith, & J. T. MacGregor's *Collaborative learning: A sourcebook for higher education* (1992), pp. 9–22. University Park, PA: NCPTLA (National Center on Post-secondary Teaching, Learning, and Assessment).

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Chapter Five
Seedlings Sometimes Grow into Very Big Trees

By Ted Wansley, Ph.D.

> *Quote from one of my biology students after we did the* Quantitative Land Cover Sample Site Protocol: *"I think this is a good idea. A lot of people don't know how fast we're using up the land and destroying trees. Reporting this (data) might help scientists get a perspective on how fast it is going away."*

The Land Cover Protocol

Using handouts to illustrate the pacing, site set-up, and densiometer construction, I detailed each step.

I received training on the GLOBE land cover protocols during the fall 1999 training session at the State University of West Georgia. Of the protocols I learned, I saw one that I could definitely use: the *Quantitative Land Cover Sample Site Protocol*. It would be a good activity to use during the plant unit of my biology classes, and I thought my environmental/science club, the Explorers, might want to try it.

My first opportunity to use the protocol came during a scheduled Explorers field trip, two weekends after the GLOBE workshop. Eighteen Explorers accompanied me on a two-day mountain stream study in the North Georgia mountains. Our chief purpose had originally been to compare the aquatic biology of mountain and piedmont streams. However, now that I had the GLOBE protocol available, it made sense for us to also compare land cover in both regions.

A Backwoods Escapade

Kids love to laugh at others when they run into spider webs, fall in holes, and run into briars, and they particularly enjoy competition-style teaming.

On the afternoon prior to our field trip, I gathered the club members together and introduced the protocols. I started off the session by asking them how they felt land cover might vary across the state. I pointed to different regions of the Georgia map and asked them to suggest what types of trees might predominate. I then asked if they would like to compare our land cover profile with that of the mountain valleys.

They seemed interested, so I introduced the *Quantitative Land Cover Sample Site Protocol*. Using handouts to illustrate the pacing, site set-up, and densiometer construction, I detailed each step. I then broke them into groups, gave them the necessary materials, pointed to the woods, and moved out of their way. They eagerly attacked the protocols and had a complete data set in one-and-one-half hours. During the process, only a few asked questions, mostly details about keeping their paces even and straight or regarding "border" disputes when one group's sample site touched or overlapped another. It was very clear that they had a good time. Kids love to laugh at others when they run into spider webs, fall in holes, and run into briars, and they particularly enjoy competition-style teaming. For some reason (I didn't suggest it), the groups started competing to make the "squarest" sample site and to finish first. Two groups were actually running to bring me their data at the end. After the sampling was completed, we compiled the data on a chart so we could take it with us on the field trip.

...the kids immediately noticed that the canopy density was greater in the mountains, and there were proportionally more hardwoods.

The next day, we repeated this same process near an Appalachian stream. The results and the fun were about the same, except that two sample sites included a creek (which they sloshed in frequently). As we looked over the compiled data tables from the mountains and Douglasville samplings, the kids immediately noticed that the canopy density was greater in the mountains, and there were proportionally more hardwoods. Afterward, when I asked students why they liked the protocol, several said that they enjoyed building the densiometers and they liked setting up their sample site in the woods. Another club member told me later that it was more interesting than she expected. She also said, "I never paid much attention to trees, but I've started noticing them a lot more since [the field trip]."

Campus Tree Planting Project

During spring semester, I used the *Quantitative Land Cover Sample Site Protocol* as a lab activity with my biology classes during a plant unit. My students were already required to produce a Tree Identification Notebook (for native species), so the protocol seemed to be a natural extension. In addition to using the densiometer to analyze land coverage, I required them to also identify the species that dominated each reading. From this information, my class determined that the wooded area behind our campus consists mostly of oak and tulip poplar. Several interesting comments came from students about the activity. Several commented on the extent of the canopy cover, and some simply said that they liked doing things outdoors. However, one student made a particularly significant suggestion, "Our campus needs help with trees," he said. "I think that it looks like a prison. Maybe we could plant some."

Our campus needs help with trees. I think that it looks like a prison. Maybe we could plant some.

Could we improve the tree coverage on our campus? I decided to ask that question at the Explorers club's next meeting. They jumped on the idea immediately and soon had a plan for a massive tree-planting project for the campus. Over the next three months, they invited a master gardener to the campus for advice, they got quotes from nurseries on available tree species, and they mapped out a plan for where the trees should be planted. They then raised money by "selling" trees and their plots to the students, faculty, and community. They even won the principal's approval for a one-half day dismissal so all those involved could plant their own tree! They called it Treescaping Day, and, on that day, 120 trees were planted on our campus. The trees were very small, but everyone agreed that it looked much better. It would never have happened if the student that suggested it had not done the land cover protocol.

They called it Treescaping Day, and, on that day, 120 trees were planted on our campus.

Over the next year, I continued to use the protocol as part of my biology class, and the Explorers worked hard to maintain the trees that were planted on Treescaping Day. Unfortunately, many trees died during the brutal summer, and approximately 30 were destroyed by the school system's maintenance staff as they trimmed the weeds and grass around them. We also received some negative comments from the county maintenance manager because we failed to solicit their approval of our plan before we began planting. This was discouraging, but the Explorers continued to water and mulch. They even purchased and planted four replacement trees and over 20 shrubs.

Treescaping Project Evolves

During this time, our Treescaping project caught the attention of a non-profit environmental organization called Rolling Hills. I showed them our biology curriculum and activities, including, of course, the land cover protocols, and I explained the Treescaping project to them. They were impressed with our school's environmental initiative and offered to help us obtain a grant so we could set our campus up as an urban forestry demonstration site. The grant would enable us to obtain, plant, and maintain at least 30 more trees. It would also pay for urban forestry speakers and related classroom materials to augment our classes. It would pay for training for our school system's ground maintenance department (to teach them how to be friendlier to our trees). The grant would also bring in a landscape architect to work with our students as they made up a landscaping plan to submit to maintenance management for approval. A field trip to several successful urban forestry projects would also be funded by this project.

In summary, we received an Urban Forestry grant for $5,000 and have just finished a week-long series of visits from forestry-related speakers to our Biology classes. We are almost finished with a professional landscaping plan that we will submit to the maintenance managers. When this proposal is accepted, we will order the trees that our campus needs.

If I'm there, I can tell them that it all started with one student's suggestion—one inspired by a GLOBE protocol.

One day, representatives from institutions such as businesses and schools will tour our campus as they plan their own urban forestry projects. If I'm there, I can tell them that it all started with one student's suggestion—one inspired by a GLOBE protocol.

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Chapter Six
Looking for El Dorado

By David Todd, M.Ed., with Rebecca Dodge, Ph.D.

"Hands-on science" and "learning-by-doing" have been popular phrases in the field of science education for longer than one "teacher" lifetime. They have risen or descended in their importance, depending on the public and political pressures of the moment. The GLOBE project is one implementation of these educational ideas that students and teachers both can embrace and get excited about.

Making Instruments for Measuring Height, Water Clarity, Overhead Cover

GLOBE is hands-on learning by doing! GLOBE encourages students to make their own instruments as often as possible, then to use those instruments to make measurements of tree height, water clarity, and overhead canopy cover, to name but a few, and to pass their measurements along to others. This promotes "acting locally and thinking globally" in a very concrete way.

GLOBE student measurements are submitted to a student data archive from which maps can be generated through the GLOBE "Visualizations" function on the GLOBE webpage.

GLOBE student measurements are submitted to a student data archive from which maps can be generated through the GLOBE "Visualizations" function on the GLOBE webpage. Accurate locations for all data points are a key element in producing accurate maps that become useful scientific documents. In addition, an accurate location for each site is required so that students can return to the same location for repeated measurements.

You Can't Build a GPS Receiver

The Global Positioning System (GPS) protocol is different. There is no practical way to create your own GPS receiver. The GPS receiver must be borrowed or bought, and the receiver is more expensive than most other GLOBE equipment. Unlike other protocols, the GPS protocol is one that need only be done one time at each measurement site. It isn't necessary to repeat it periodically, since the study location would only move with the geological plate upon which it is located, and that movement is slow enough to be ignored for GLOBE purposes.

The GPS receiver must be borrowed or bought, and the receiver is more expensive than most other GLOBE equipment.

Cooperative Learning and Student-Teacher Teamwork

Because the GPS protocol involves only one measurement for a study location and only the one GPS receiver, teachers and students typically work closely to make the protocol position measurements. This student-teacher teamwork can be the opening for continued cooperative learning throughout the GLOBE experience and, it is to be hoped, throughout the student's school/science experience. Student teams are one of the most fundamental elements of the GLOBE experience. Student team members learn important skills about cooperation and teamwork. These skills assist them in every phase of their school experience and, later, in life.

GLOBE Students Coming to Alexander

At Alexander High School, we view this multiple-year involvement in GLOBE as being a very powerful tool to promote science literacy and community involvement in the educational process.

At Alexander High School, our required GPS location measurements were made several years ago by Dr. Gail Marshall and Mrs. Peggy Baugh and their original group of GLOBE students. And our annual influx of new ninth-grade students have already been introduced to GLOBE by Mrs. Rhonda Baldwin at Fairplay Middle School, our single largest feeder school. Mrs. Baldwin's very active and enthusiastic GLOBE Program enables these students to bring good GLOBE experiences and excitement about science and GLOBE with them. At Alexander High School, we view this multiple-year involvement in GLOBE as being a very powerful tool to promote science literacy and community involvement in the educational process.

Historical Problems with Finding Latitude and Longitude

Knowing exactly where you are on the globe of the earth, closer than some number of tens of miles is a somewhat modern ability.

Knowing exactly where you are on the globe of the earth, closer than some number of tens of miles is a somewhat modern ability. Since the time of the Greeks, at least, people in the northern hemisphere have known how to measure the angle of Polaris, the North Star, above the horizon, to get a pretty good idea of their latitude. And knowledgeable travellers can always tell their latitude, well enough, by the length of the day, the height of the sun, or any known guide star above the horizon. But that information alone, without knowing longitude, puts one on a circle, so many degrees south of the North Pole or north of the equator that completely circles the earth!

Christopher Columbus was able to navigate westward along one such latitude line, or "parallel," knowing he was not straying too far north or south of his desired course, but his ability to determine how far west he had gone was very suspect. One way of attempting to determine the distance travelled was to toss a floating log overboard and measure the time it took for a given number of equally spaced knots that were tied in the log's tether to be drawn through a sailor's hands. Hence the modern naval speed unit of "knots," or nautical miles per hour. Keeping a running calculation of speed in knots and hours or days of sailing time allowed the captain or the navigator to determine the distance travelled. The effects of drifting due to currents or cross winds could only be guessed—hence, the term "dead reckoning." Reckon well or be dead!

The knotty problem of determining longitude, or east-west movement around the globe from some fixed point, has plagued men at sea for most of human history. Even in the age of Greek mythology, any travel west of the gates of Hercules, beyond modern Gibraltar, into the Atlantic Ocean was a virtual sentence of death because of

the difficulty of navigation anytime the sailor was beyond sight of land. Dava Sobel explains the problem and its eventual solution by a watchmaker in her book *Longitude*. Sobel points out that determining longitude at sea requires that a sailor know his local time, determined by the sun and the earth's rotation, and the time at his home port, simultaneously. One hour's time difference corresponds to 1/24 of a day, or 1/24 of the circumference of the earth, or 15° longitude.

No clock aboard a moving ship was capable of the necessary accuracy for a reliable longitude fix until 1773. This had become a very important problem of national security to the major powers in the early 1700s. Such a large problem that several kings, England and France in particular, established large monetary prizes, to be awarded to the person who could solve the "problem of determining the longitude at sea."

Admiral Clowdisley Shovell

For example, on October 22, 1707, Admiral Clowdisley Shovell and a fleet of five British warships, returning from patrol in the Bay of Biscay, ran aground on the Scilly Isles, off the southwest tip of England with the loss of four ships and 2,000 souls because of a mistake in determining their longitude. Sobel's book is a treasure trove of such adventure and stories like the struggles of John Harrison, self-educated clockmaker and the inventor of the first "chronometer" accurate enough for navigation. Harrison's chronometer was described by Captain James Cook, aboard *H. M. S. Resolution* in 1776, on his return from the south Pacific, as "...our faithful guide through all vicissitudes of climates."

Andrew Ellicott and the Louisiana Purchase

During the 1790s, the Harrison chronometer was the equivalent of a commercial secret weapon, just one of the underpinnings for the naval prowess of the British navy in the 18th century. That's why Andrew Ellicott, the surveyor of Washington, D.C., had to use different methods when he surveyed the Mississippi River in February, 1797, to establish the borders of the new United States of America for President George Washington. As already mentioned, determining longitude is a matter of comparing times between the unknown place and some known place. Ellicott brought with him to the Louisiana frontier a pendulum clock, a telescope, and some numbers from a book. He was able to set his pendulum clock to local time using a guide star.

Philip Morrison, Professor Emeritus, Massachusetts Institute of Technology, and his wife Phylis Morrison re-enact this adventure in their video essay and book, *The Ring of Truth: An Inquiry into How We Know What We Know*. The Morrison team travels to Ellicott Hill, near Natchez, Mississippi, and uses the star

Spica, in the constellation Virgo, to set their clock to the correct local star time. Wherever you are on earth, when you see Spica at the top of its arc, your local star time is 13:24 hours. Determining when the star is at the peak of its broad, gentle arc is a big part of the challenge. The observation of Spica gives the local star time, which is used to set the pendulum clock. Now they need the time at some other, well-known location.

One of Mr. Harrison’s chronometers, set to the time in Greenwich, New York, or Washington, D.C., would do the trick nicely at this point. But the United States in 1797 was small and poor, and the British were still treating the new chronometer like a secret weapon. Ellicott did not have one.

The Italian scientist, Galileo had provided the solution to Ellicott’s problem of time more than 200 years earlier. He had used his telescope to observe the moons of Jupiter: Io, Ganymede, Callisto, and Europa, now referred to as the Galilean moons of Jupiter. Galileo kept careful notes and sketches of the moons as they moved to and from one side of the planet to the other. He explained this side-to-side motion as being circular orbits of the moons around Jupiter as seen from the side. That explanation and Galileo’s hard-headed belief caused some serious problems between Galileo and Pope Urban VIII, but that is another story. Galileo soon realized that the positions of the moons could be used like a clock by a trained and dedicated observer. In 1676, Danish astronomer Olaus “Ole” Roemer, making those observations, noticed a 22-minute discrepancy in the time that Io takes to orbit Jupiter. Christian Huygens, a Dutchman, explained Roemer’s observed time delay in Io’s orbit as being due to differences in the distance between earth and Io. Huygens calculated the speed of light from the observation, being one of the first to attempt the measurement. Huygens also patented the pendulum clock.

Galileo had the idea that the moons of Jupiter could be used as a great navigational clock in the sky, but it fell to another Italian, Jean-Dominique Cassini, at the Observatoire de Paris, to make it a practical reality. Cassini and the observatory staff observed, timed, and recorded the movements of the Galilean moons well enough to predict their movements and times a year or more in advance. Anyone with a good telescope and a stable place to mount it for observation could determine their local star time and using Cassini’s tables, could know the star time in Paris, from anywhere on earth.

So the numbers Ellicott brought with him to the borderland between the United States and Spanish territory in 1797 were extracts of Cassini’s tables for the moons of Jupiter. These tables allowed Ellicott to make the comparison between his local time, determined by Spica, and the time in Paris, determined by the Galilean moons and Cassini's tables and, therefore, to place himself so many hours and minutes west of Paris and within a mile or two of his exact location in longitude. A pretty involved process but effective in the hands of an expert like Andrew Ellicott. Just a few years later, the explorers, Meriwether Lewis and William Clark carried with them on their explorations of President Jefferson's Louisiana Purchase a chronometer, copied from John Harrison's design, that allowed them to determine their distance traveled west. (Ellicott trained the explorers in the use of the chronometer and how to reset it on those occasions when they forgot to wind it, and it stopped.)

The GPS is a navigational system that depends on timing signals produced by a network of 24 satellites placed in orbit by the U.S. Department of Defense.

What is GPS?

Latitude and longitude have always been important to people who need to know where they are. Until the invention of Harrison's chronometer, the longitude half of the "where am I?" question was difficult to determine. Since the mid-1980s, however, the Global Positioning System (GPS) has transformed this once life-or-death, tedious problem into electronic simplicity, even recreation. The chronometer carried by Lewis and Clark cost more than all of their "mathematical instruments" combined. The modern GPS receiver is as small as a cell phone (or even smaller) and costs as little as $100.

A GPS unit receives signals from several satellites simultaneously.

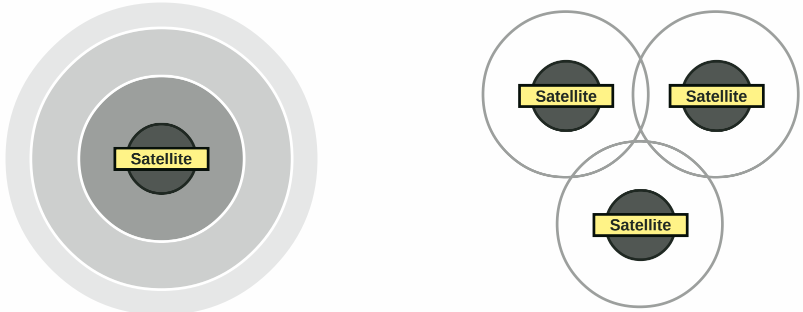
GPS Technology Today

The GPS is a navigational system that depends on timing signals produced by a network of 24 satellites placed in orbit by the U. S. Department of Defense. Originally designed for a variety of military purposes, it was made available in the mid-1980s for civilian use.

How It Works

A GPS unit receives signals from several satellites simultaneously. Each satellite contains three atomic clocks for very accurate timekeeping. The GPS unit is able to calculate its distance from the signal source based on time of travel of the signal compared to time stored in the receiver. (This makes a GPS receiver the best source of accurate time in most locations.) Signals received from three different satellites allow the unit to calculate two-dimensional positions, latitude and longitude, by triangulation (see Figure 1 on the following page). The single point where the three radio signals overlap is the receiver's location. Signals received from four or more satellites allow three-dimensional positioning, latitude, longitude, and altitude. When originally made available for civilian use, the signal was artificially degraded, a technique called selective availability, to deny the most accurate data to potential enemy military forces. Selective availability was ended on May 1, 2000, automatically improving the accuracy of existing GPS receivers about ten times. The user of consumer-grade receivers can expect accuracy of 7–15 meters (21–45 feet) in ground position and +/- 35 meters in altitude. Some environmental factors can interfere with accuracy. This puts the GPS receiver well within the 30x30 meter pixel size of Landsat satellites images used in the GLOBE Program.

Figure1



Satellite transmits a signal that moves outward in concentric circles at the speed of light.

GPS receiver triangulates its position to the place where the signals from three or more satellite signals overlap. The satellite positions are "known."

GLOBE Use—One Time for Study Sites

The GPS protocol is the only "one-time-only" protocol. Students have to determine the latitude, longitude, and altitude of their school entrance, which is the center of their GLOBE Study Site. Then the position of the atmosphere study site rain gauge and instrument enclosure is determined. As they are added, the hydrology, biology, land cover, soil characteristics, and soil moisture site centers are located using the GPS.

Classroom Learning Activities

The GPS section in the GLOBE manual lists several learning activities that can be very useful in several different science class situations. The following is a brief look at each activity and some possible uses in class.

What is the Right Answer?

It can be very useful in a physics or an astronomy classroom to introduce the concept of uncertainty.

This activity calls for comparing the time indicated on a variety of clocks and watches simultaneously. It can be very useful in a physics or an astronomy classroom to introduce the concept of uncertainty. The worst reputation of the physics classroom is that it is a place of impossible mathematical detail, unreasonable concentration on answers, and the most careful measurement of the most unreasonably small differences. Of course, that is not what physics is about, but all too often that is what the student expects. This is a good activity to show that there are a variety of possible answers to a question, and the activity can be a good exercise in how to come to agreement on the best of several possible answers.

Relative and Absolute Directions

This activity deals with distinguishing between and describing relative and absolute directions. It works well for helping physics students understand parallax, and it is one of the fundamental skills that an astronomy student needs. It is a good way to learn to understand about differences in measurements based on different points of observation in orbital frames of reference.

Working with Angles

This activity is a beginning class in observational astronomy and the history of astronomy. Lots of mathematical skills are learned or honed.

Celestial Navigation

In this activity, the students make a modern recreation of Eratosthenes' famous experiment to measure the diameter of the spherical earth (more than 1500 years before Columbus' peers were supposed to have thought that the earth was flat). They make contact with and communicate with students from another school, at least 500 kilometers away, and compare their locations. It's a great exercise for kids of all ages. My high school senior students even get excited about this one!

Other Activities

The activities in the GLOBE GPS protocol, like all of the GLOBE activities, are engaging and very concrete.

The activities in the GLOBE GPS protocol, like all of the GLOBE activities, are engaging and very concrete. They emphasize the connections between science and math, social studies and global involvement. And the skills used in the GLOBE protocols transfer into lots of other areas.

GPS Orienteering and Geocaching

The GPS system has even begun to be made a part of a large-scale recreational activity. For years, the Boy Scouts of America and many different recreational-fitness-sports organizations in Europe have promoted orienteering as an educational and fitness activity for individuals and families. It involves taking a map, a magnetic compass, and a set of written instructions and moving from some starting point to checkpoints inside forests and parks to find specific locations. Usually the location is identified by a small marker that can only be seen when one comes near. Also, the location often has code words, further instructions, a speciality hole punch, or a logbook to use as proof that one has successfully found the location. Awards, often only "bragging rights," are given to those who find the locations.

Volunteers establish "cache" (think of the Arctic explorers' practice of establishing stored food, fuel, and equipment for later use during a trek) locations in forests or parks that they enjoy and that they would like to share with others.

There is a new variation of this activity that centers on the GPS capability of finding a single, narrow point in unfamiliar places. This new recreation is called geocaching. Volunteers establish "cache" (think of the Arctic explorers' practice of establishing stored food, fuel, and equipment for later use during a trek) locations in forests or parks that they enjoy and that they would like to share with others. They hide the cache in a weatherproof container (Tupperware container or Army surplus ammo box) containing a logbook and sometimes trinkets. Then they post cryptic hints/clues about the location, along with its latitude and longitude, on dedicated websites. Finally, interested people seek and find these locations and post their impressions on the website. They sign the logbook and take one of the trinkets, leaving one of their own for the next finder. It is a good excuse to get out of the house on weekends and into some of the more interesting places in the area.

Conclusion

The GPS protocol is a great introduction for teachers and students to GLOBE. It ties in to some of the most up-to-date technology in use today. It provides tie-ins to scientific, educational, and recreational activities that are of interest to teachers, students, and families. Check out the GLOBE GPS protocol and start looking for El Dorado!

Sources and Resources

Asimov, I. (1972). *Asimov's biographical encyclopedia of science & technology*. New York: Doubleday & Company, Inc.

Geocaching. (2001, July 6). *ABC Evening News* [Television Broadcast]. New York: Public Broadcasting Service.

Gundersen, P. E. (1999). *The handy physics answer book*. New York: Visible Ink Press.

Kuhn, K. F. (1994). *In quest of the universe*. New York: West Publishing Company.

Klinkenborg, V. (December, 1999). No place to hide. *Discover Magazine*.

Morrison, P., & Morrison P. (1989). *The ring of truth*. New York: Vintage Books.

Sobel, D. (1995). *Longitude: The true story of a lone genius who solved the greatest scientific problem of his time*. New York: Walker Publishing Company, Inc.

Sobel, D. (1999). *Galileo's daughter: A historical memoir of science, faith, and love*. New York: Walker Publishing Company, Inc.

Websites

http://128.143.22.23/exhibits/lewis_clark/ch4-28.html
Information about Andrew Ellicott and his connection to the Lewis and Clark expedition.

www.geocaching.com
One website with many links to other geocaching sites.

www.garmin.com
One of the manufacturers of consumer GPS products with basic information/background.

www.GLOBE.gov
The place for everything about the GLOBE Program.

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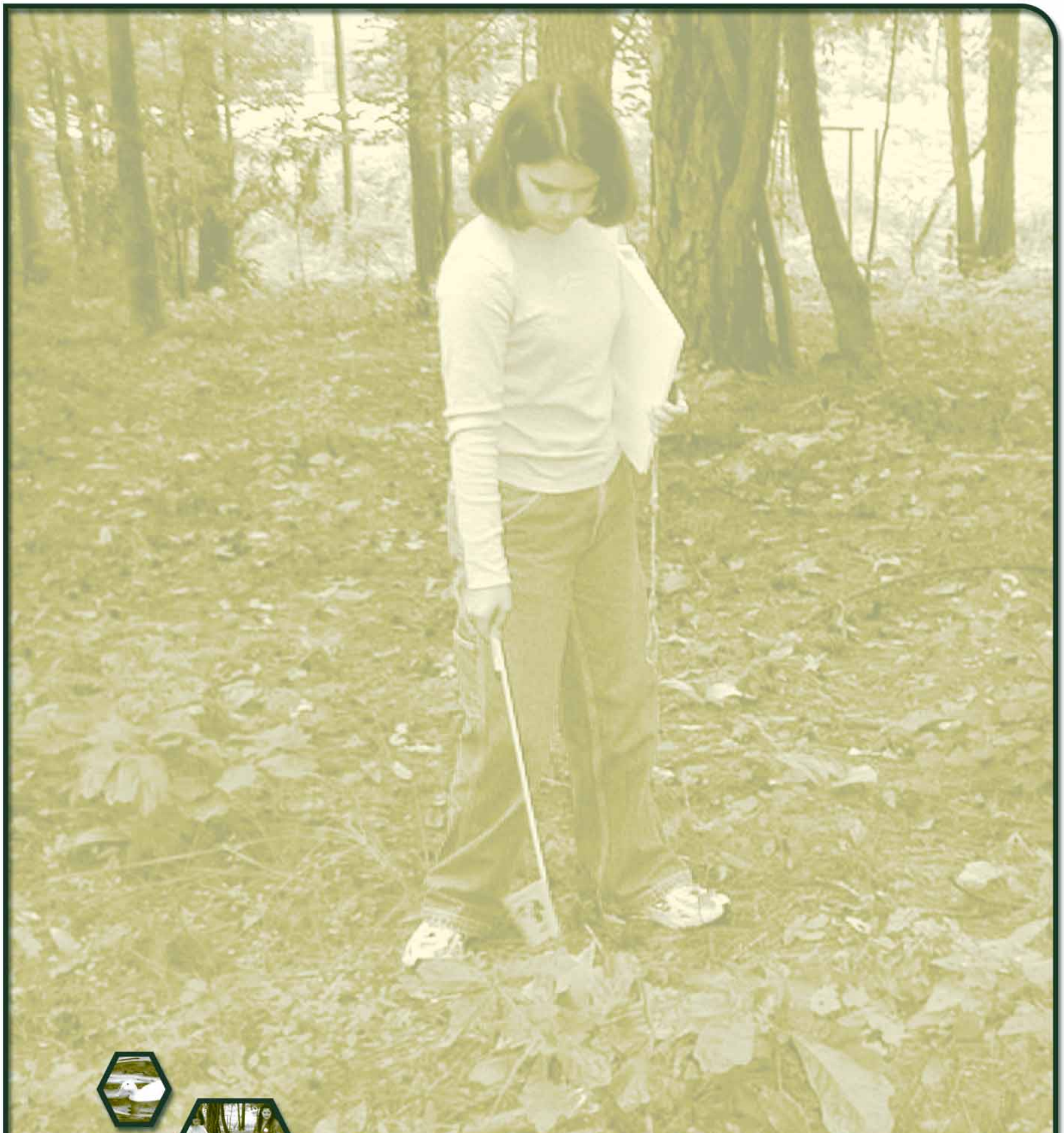

Chapter Seven

Impacts of GLOBE Lead to Gatekeepers of the Future

By Terrie Kielborn, Ph.D.

> *The world looks so different after learning science. For example, trees are made of air, primarily. When they are burned, they go back to air, and in the flaming heat is released the flaming heat of the sun, which was bound in to convert the air into the tree. [A]nd in the ash is the small remnant of the part which did not come from the air, that came from the solid earth, instead.*
>
> *These are beautiful things, and the content of science is wonderfully full of them. They are very inspiring, and they can be used to inspire others. (Feynman, 1996, p. viii)*

Impacts From Our First GLOBE Training Experience

Often impacts are not known immediately. Our first GLOBE training at the University of West Georgia (UWG) has witnessed a number of outcomes and will most likely host more in the future. The following is a partial list of some of the major impacts from our first GLOBE Training experience:

- Curriculum changes in the Early Childhood Program of Study at UWG
- Distinguished Professor Grant between College of Education and College of Arts and Sciences, UWG
- Environmental Techniques Course, Summer 2000, team-taught by College of Education and College of Arts and Sciences, UWG
- Collaboration with local schools using GLOBE
- West Georgia as a GLOBE Partner
- Environmental Observations for Teachers Course, Spring 2001, team-taught by College of Education and College of Arts and Sciences, UWG (one of two universities to teach GLOBE as a course for pre-service teachers for the first time)
- Students and Teachers Are Revitalizing Teaching through Technology) START Conference
- Project ROW (Restoring Our Waters)

One of the initial impacts from our first GLOBE training held with Georgia TECH was the award of the Distinguished Professor Grant to a group of faculty representing the College of Education and the College of Arts and Sciences at UWG. This grant provided funding for a new course, *A Problem-Based Approach to Teaching Environmental Science,* offered at the undergraduate and graduate levels. The undergraduate course targeted science majors (biology, chemistry, geology, geography, and environmental science), while the graduate course focused on in-service K–12 teachers. For this course, students performed a preliminary assessment of a local watershed and developed and conducted research on a topic related to water quality over the summer. Students obtained their data through the use of graphing calculators, probes, and sensors in combination of some of the GLOBE protocols.

UWG Becomes a GLOBE Partner

My interest in GLOBE and involvement with the collaboration at Bremen High School's environmental science course prompted me to submit a proposal for a small grant to attend a GLOBE Train-the-Trainer workshop where I would become a certified GLOBE trainer. It is important to note that in order to be a Certified GLOBE Trainer, you must attend and receive certification for GLOBE training. In addition, teachers can only become GLOBE-certified by participating in a GLOBE workshop facilitated by GLOBE trainers.

...within a month, UWG became an official GLOBE partner.

A colleague from the College of Arts and Sciences, Department of Geosciences, Rebecca Dodge, had previously been trained as a GLOBE trainer as well as directed a GLOBE partnership in EL Paso prior to her position at UWG. Since I shared Rebecca's desire for UWG to be a GLOBE partner, we had a few meetings and decided to make a presentation to the programs/funding director at UWG regarding possible monies to be allocated for the GLOBE program under the auspice of UWG as a GLOBE partner. The meeting was favorable; Rebecca submitted the paperwork for our GLOBE partnership; and within a month, UWG became an official GLOBE partner. Georgia currently has three GLOBE partners: Georgia Institute of Technology, FernBank Museum, and UWG. FernBank's primary focus is the DeKalb School System since they have listed the GLOBE curriculum as matching the requirements of their county curriculum as well as the state standards. Georgia TECH has a considerable number of trainers, but since it does not offer programs of study for education majors, it requires the assistance of other institutions with educational programs in order to train in-service or pre-service teachers in GLOBE. Currently within the Department of Geosciences at UWG, more faculty are being GLOBE-trained and students and teachers are becoming GLOBE-certified through both undergraduate and graduate-level courses.

Teaching GLOBE as a Course

Due to the success of the courses provided by the Distinguished Professor Grant, continued interest, and training of additional faculty, a curriculum change in the program of study for early childhood education majors took place a year later. The change required GLOBE to be taken as part of their program of study to satisfy science hours in the freshman or sophomore year. The course was offered through the College of Arts and Sciences, Department of Geosciences, and students received three hours of undergraduate credit. The Spring 2001 semester was the first time for the course to be taught at UWG. Students attended a one-hour lecture twice a week to learn about geosystems and then attended a two-hour laboratory once a week to be trained in all of the GLOBE protocols.

Rebecca Dodge of Geosciences presented the lecture-series of the course. Rebecca and I team-taught the two-hour laboratory sections using the GLOBE learning activities and protocols as our curriculum. We had two sections of laboratory because we wanted to keep the ratio of teacher-to-student low for practicing and conducting the GLOBE protocols. Students worked in small groups of three or four to conduct various learning activities in the laboratory or outside.

After students learned the procedures for a particular protocol, they were able to apply what they had learned outside. It is amazing to witness college students conducting authentic science for the first time. This particular group was also able to work with a group of middle school students from Sewell Middle School, approximately 15 miles northeast of UWG. This experience allowed middle school students to actually collect scientific data alongside college students and to get a first-hand glimpse of what college is like. It also provided the opportunity for this group of education majors to work with middle school students.

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Project ROW

Project ROW (Restoring Our Waters) was developed as a result of UWG faculty from the College of Education and the College of Arts and Sciences at UWG participating in the Student Teachers are Revitalizing Teaching through Technology (START) Conference in the fall of 2001. The focus of this conference was for each team to develop a program utilizing instructional technology.

Project ROW is a collaborative effort of the University System of Georgia, private institutions, professional organizations, state and government environmental agencies, and corporate sponsors. It is a statewide initiative to train in-service teachers and students to use technology for conducting water quality research on Georgia's major rivers and tributaries. The project consists of three stages: training, implementation, and assessment/evaluation. The training phase will prepare teachers to use technology and protocols for conducting water quality studies. During the implementation phase, teachers will apply what they learned in the training phase and conduct an action research project at specific point sources. To fulfill the assessment phase, the teachers will present findings of their research at an Environmental Summit in Atlanta.

[Project ROW] is a statewide initiative to train in-service teachers and students to use technology for conducting water quality research on Georgia's major rivers and tributaries.

Gatekeepers of the Future

This monograph was devoted to the idea of using GLOBE as a method of enabling students to learn about their environment by conducting their own authentic science investigations. "Students are empowered and motivated by involvement in GLOBE" (Butler & Coppola, 1997, pp. 69–70). GLOBE is designed to motivate learners of varying abilities and of any ethnic or cultural background. Georgia has a large diverse student population

GLOBE is designed to motivate learners of varying abilities and of any ethnic or cultural background.

particularly throughout the metro-Atlanta area. Therefore, a curriculum must address a variety of cultures and languages if it is to be appealing to school systems. “GLOBE educational materials are provided in the six United Nations languages: Arabic, Chinese, English, French, Russian, and Spanish” (Finarelli, 1998, p. 83). GLOBE students from around the world enter their data daily on the GLOBE website [*www.globe.gov*], allowing students to learn about GLOBE data from other countries.

The Teacher Research Education Council (TERC) and the Concord Consortium (1997) recommend these types of science experiences because they give students “the scientist’s sense of wonder, the scientist’s sense of hope, the scientist’s sense of accomplishment, the scientist’s sense of how we explain our universe” (Pennypacker, 1997, p. 50). Students begin to think of science the way scientists do.

The chapters in this monograph reflect just a portion of the impact GLOBE has had on the students in Georgia. Rhonda’s excitement led to a student’s grandfather constructing the instrument shelter to “perfection” and her students raising enough money in a week’s time to receive most of their GLOBE supplies. In her chapter, she states, “I found my students working together to reach our goals—financially and academically.” She observed her students working enthusiastically and cooperatively to collect data. One student even commented, “Once the GLOBE Program is over, I plan to still keep collecting data over the summer.”

Staci found that GLOBE provided “clear and concise packages of information” to allow her ecology students one set of instructions versus the compiled version she had been using prior to her GLOBE training. In fact, the class using the GLOBE protocols for instructions “worked and accomplished the most.” Staci attributes the success of her students to the GLOBE protocols that were detailed and specific so “the students had little, if any, questions or difficulties.”

Carla was able to convince her administration to begin offering an environmental science course at her high school. She began by seeking assistance from UWG to co-write a grant that she received to purchase her equipment and supplies for GLOBE. I spent as much as three days a week co-facilitating the use of GLOBE protocols with her students. Her students enjoyed carrying out GLOBE protocols because it allowed them to spend time outside the classroom as well as in the laboratory. In addition, the students learned how to relate what they learned using GLOBE with their own local environment by sharing weekly articles on environmental issues from their local newspaper. Finally, her students demonstrated many of the soil protocols with sixth-grade students at a nearby middle school. Carla comments, “It was a very positive experience for both....The sixth-graders learned about soil, while the high school students shared information and procedures that they had previously learned through the environmental science class."

Ted began using GLOBE with his environmental/science club, the Explorers, in the North Georgia mountains. His students enjoyed building densiometers and walking through spider webs. One of his students commented, "I never paid much attention to trees, but I've started noticing them a lot more since [the field trip]." For Ted and his Explorers, this was a new beginning. After raising money, seeking advice from master gardeners, and mapping out a plan, the group planted a variety of trees on their school campus. It was even given a name, *Treescaping Day!* No doubt, since they planted 120 trees. This success bred a new project involving various community partners and a $5,000 Urban Forestry grant. Ted remarks, "It all started with one student's suggestion, one inspired by a GLOBE protocol!"

David has the luxury of inheriting students already exposed to GLOBE protocols because many of his students come from Rhonda's school. David's protocol is unusual in that it involves a piece of equipment that cannot be made but must be purchased and requires a once-a-year collection. He comments in his chapter that the GPS protocol "ties in to some of the most up-to-date technology in use today." He also discusses how using the GPS has become a recreational activity—especially for groups such as the Boy Scouts. He encourages all of us to check out the GLOBE protocols and begin looking for El Dorado.

Even though these five teachers represent a micro-fraction of the 16,000 GLOBE-trained teachers throughout 96 countries, the impact that they have already made on students is astounding. It is safe to assume that the impact we have witnessed in Georgia is taking place worldwide, and that the teachers who become GLOBE-trained in the future potentially will have that much more impact.

Through GLOBE, students can experience the excitement of doing authentic science using a hands-on and field-experience approach. GLOBE provides "the linkage of school learning with the real world" (Barstow, 1997). When students learn about their environment, they learn about what affects the water they drink and the food they eat.

As educators, we know first-hand that the students we teach today will be the leaders of our country tomorrow. As scientists or science educators, we know how important it is for these "prospective leaders" to make decisions that will provide protection and sustainability for future generations to come. Before decisions can be made, there must first be an awareness that will allow the problem to be recognized. Once the problem is identified and accepted as a dilemma, various perspectives are

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Today's students are our gatekeepers of the future.

needed to develop sound, feasible, and reasonable solutions. All of this responsibility for the future rests on the students of today. The time to begin their training is now in classrooms around the world. Today's students are our gatekeepers of the future.

References

Barstow, D. (1997). The richness of two cultures. In TERC & The Concord Consortium, *Student and Scientist Partnerships (SSP) Conference* (pp. 33–37). Cambridge, MA: TERC & SSP Conference.

Butler, D., & Coppola, R. K. (1997). GLOBE. In TERC & The Concord Consortium, *Student and Scientist Partnerships (SSP) Conference* (pp. 69–70). Cambridge, MA: TERC & SSP Conference.

Feynman, R. Quotation. In National Research Council (NRC). (1996). *National science education standards.* Washington, DC: National Academy Press.

Finarelli, M. C. (1998). GLOBE: A worldwide environmental science and education partnership. *Journal of Science Education and Technology,* 77–83.

GLOBE (Global Learning and Observations to Benefit the Environment), *www.globe.gov.*

Pennypacker, C. (1997). Why do scientists want teachers and students to do real research? In TERC & The Concord Consortium, *Student and Scientist Partnerships (SSP) Conference*, (pp. 48–52). Cambridge, MA: TERC & SSP Conference.

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Georgia Goes Global: Monitoring the Global Environment through Authentic Science relates the experiences of five in-service teachers who participated in the GLOBE training workshop. Each teacher implemented a specific GLOBE protocol in his or her respective educational setting. The concept was to illustrate how implementing the protocols provides a venue for students to engage in authentic science as active participants in the learning process and become self-directed researchers. These experiences also convey how the GLOBE curriculum enhances students' ability to think scientifically through "contextual learning." The concluding chapter discusses the impact of the GLOBE Program and how it precipitated other projects as an outcome of the GLOBE experience.

"True science teaches us to doubt and to abstain from ignorance. Man can learn nothing unless he proceeds from the known to the unknown."

—Anonymous

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