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Using the GLOBE Program to Educate Students on the Interdependence of Our Planet and People

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We present how we have used GLOBE protocols and programs in a college undergraduate English course for science and non-science majors, "Writing in the Sciences", and in a graduate-level field course for in-service teachers. Collecting land cover data and determining biomass in conjunction with a series of writing assignments allowed the English students to connect their work to research done in ecosystems throughout the world, and to specific environmental concerns such as carbon sequestration, biodiversity, and the impact of controlled burning on ecosystems. Teachers demonstrated increased knowledge of ecology, natural histories of various organisms, and awareness of environmental resources. A study conducted the following summer revealed that teachers valued the course and felt that their experiences helped them be more effective teachers. Six of the eight teachers had conducted field activities with their students, but also reported significant challenges associated with the effort.

Keywords: GLOBE Program; Teacher Education; Biomass; Non-Science Majors; Environmental Education

Introduction

The GLOBE Program (Global Learning and Observations to Benefit the Environment) promotes the acquisition of the process concepts and skills stressed in the *National Science Education Standards*: identifying a problem, designing an experiment, identifying variables, posing questions, making accurate observations and measurements, using equipment properly, detecting measurement errors, using math to solve problems, explaining data and its measurement relationships, presenting data, communicating results, and presenting findings in multiple formats (NRC, 1996). Students can measure, conduct data analysis, and submit actual field data (i.e. pH, dissolved oxygen, turbidity, invertebrate counts, land cover, etc.) collected during their investigations to the GLOBE Student Data Server. This data is available to students and scientists for analysis.

GLOBE is an interagency program funded by NSF, NASA, NOAA, and supported by the US Department of State. In addition, over 100 countries manage and support this program in elementary and/or secondary education. The GLOBE Program has enabled us to incorporate authentic scientific investigations and field experiences into a variety of undergraduate students and graduate courses for science teachers (www.GLOBE.gov). In addition, the program allows us to promote environmental stewardship and is a vehicle for service-learning.

The GLOBE Program includes multiple protocols divided into four areas: atmosphere, Earth as a system, hydrology, land cover/biology, and soil. As the first author is a biology educator and a GLOBE partner, we focus on land cover/biology and hydrology protocols and its new program, "Investigating the Carbon Cycle in Terrestrial Ecosystems" (http://GLOBE carboncycle.unh.edu/). The Modified UNESCO Classification or "MUC" is used for reporting the type of land cover in a study site (typically a 30 square meter area). MUC codes range from natural to developed; wetland to grassland; rivers to oceans; and everything in between. Recently, a cell phone app has been developed for ease in determining the MUC code of a study site. Land cover/biology data is collected from a study site and includes photographs taken in the center of the site from the four cardinal directions, the tree height and circumference of sample trees, and the type and percentages of ground and canopy cover. The Carbon Cycle program adds tree identification and requires obtaining the height and circumference of every tree over 5 meters tall in the study site. A camera, compasses, tape measures, string, and flags are needed to mark off the site. Tree height is calculated using a tape measure and a simple hand-made clinometer based on a printed copy of a protractor template. (Tangents for angles are provided on the reverse side of the template.) Tree circumference is measured with a tape measure at a standard height from the ground. Canopy and ground cover is measured on the diagonal transects of the study site. Data is collected every two paces using a hand-made densiometer and visual observations. **Figure 1** is a photograph of the equipment used to collect land cover/carbon cycle data. **Table 1** provides a simplified procedure for collecting land cover data.

With the program "Investigating the Carbon Cycle in Terrestrial Ecosystems", students can determine the biomass of the study site, compare it to other sites, and/or make comparisons

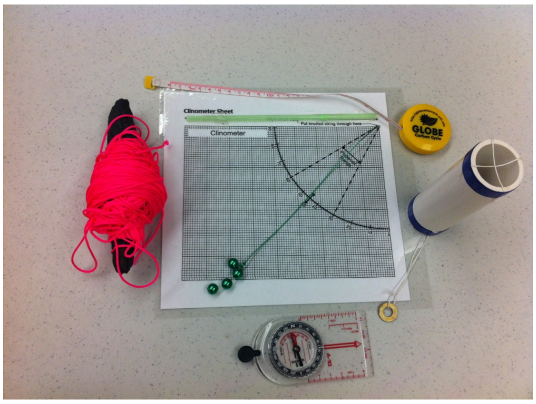

Figure 1.
The home-made and inexpensive equipment used for data collection: string, clinometer, measuring tape, densiometer, and compass.

Table 1.
Simplified procedures for collecting land cover data and carbon cycle data.

Step	Procedure
1	Measure off and mark a study site (*i.e*. 30 m × 30 m) using a compass and measuring tape.
2	Mark 2 diagonal transects (from each corner to the other).
3	Take measurements every 2 paces along these transects using a densiometer to determine canopy cover and simple observation to determine ground cover.
4	For each tree at least 5 m in height in the study site, record its common name, determine the circumference at breast height using a measuring tape, and height using a clinometer and measuring tape.

across time. For this purpose, biomass is a measure of the amount of carbon stored in the trees, and is determined by measuring tree circumference and using species-specific coefficients as reported by Jenkins et al. (2003). The program provides a spreadsheet that automatically calculates biomass. Students must enter the dimensions of the study site and the tree type and circumference of *each* tree in the site. The carbon cycle is an essential piece of ecological processes such as plant growth and accumulation, and the death and decay of plant material. At the global scale, the carbon cycle influences Earth's climate by regulating the amount of carbon dioxide, a major greenhouse gas, in the atmosphere. Because land-based ecosystems store as much carbon as the atmosphere, plants and soils play an important role in regulating climate.

We have used GLOBE protocols and programs in a college undergraduate English class for non-science majors "Writing in the Sciences"; a biology methods class for pre-service teachers, a graduate-level field course in Florida for in-service teachers; and grant-funded outreach for K-12 students and professional development for their teachers. In this article, we present two of the ways we have incorporated the program and the results we have obtained.

Undergraduate Course in Advanced Composition: Writing in the Sciences

Methodology

For the writing students, the GLOBE program helped provide the perfect opportunity to investigate the intersection between writing and science, as well as the intersection between science and socio-political issues. Students were required to compose a research portfolio which included a proposal, annotated bibliography, primary research article, and poster paper presentation. The research portfolio enabled students to present data collected using the GLOBE biometry protocols which measured biomass, tree circumference, tree height, ground cover, and canopy cover.

The first part of their portfolio was a proposal based on the research and grant proposals that researchers are often asked to write in the course of their projects. These proposals are often read, analyzed and approved by a diverse range of audiences including non-technical audiences in granting agencies, scientists in other fields, and scientists within their own field. The students needed to be able to accommodate those various audiences by framing their research to the needs and interests of that audience. One of the learning outcomes for the class required that students develop rhetorical awareness: to be able to meet the needs and expectations of various audiences. The research portfolio fulfilled this outcome because it allowed them the opportunity to research and write for a variety of audiences.

The second step in the project was an annotated bibliography which asked students to demonstrate their ability to research within their field. Students were required to locate primary, peer-reviewed research articles that related to their experiment in order to understand the niche that their own data collection filled. The audience for this annotated bibliography is scientists interested in their research, but not necessarily in their field.

Students were then asked to produce a primary research article that incorporated their research from the annotated bibliography and presented the data collected from the GLOBE protocols. Students were asked to write for an audience of scientists within their field, and to adopt the conventions of scientific communication. For the final stage of their project, students presented their findings during a poster paper session at the end of the semester.

Results

In their proposals, students recognized how people in the city and surrounding areas might be impacted by research on biomass. Many students focused on the benefits that could be experienced by the immediate community, while others focused on the impact on local industry. For example, one student proposed to study biomass in order to create economic incentives for farmers:

"*Tree farms in Mississippi aid in increased carbon sequestration. The introduction of an economic incentive package for Mississippi farmers could intensify the produce of carbon sequestration by prolonging tree life until carbon sequestration has met maximum capacity.*"

Another student proposed studying biomass as part of a larger project concerning local environment, which would aid governmental decisions concerning zoning and land use. The students stated that "*understanding each region's contribution to plant biomass and their carbon retention ability can thus provide further value of flora to locals and help guide land use management.*" Similarly, another student connected the need for better governmental policies to an improved understanding of the local environment:

"*An intense survey of Forrest and Lamar counties for the purpose of collecting animal population, species and community biomass data would be invaluable to understanding the condition of our locale and provide guidance to governing parties in forming environmental regulations specially designed to address the needs of the Pine Belt.*"

As we can see in the previous examples, the proposal assignment enabled the students to focus on local community needs and concerns that necessitated scientific research. The next step was to conduct the field research.

Our university is fortunate to have a stand of long-leaf pines, *Pinus palustris*, in close proximity to the campus. These once dominant trees have largely been replaced by loblolly and slash pines across the southeastern portion of the United States. Students collected data in a controlled burn area in the Long Leaf Preserve during one semester and a mixed hardwoods bottomland forest during another. After marking off a 15 square meter (m^2) study site, students determined ground cover and canopy cover, but tree circumference is the only measurement used to calculate biomass. **Table 2** shows the tree circumference of the eleven long-leaf pines ranging from approximately 71 centimeters at breast height (CBH) to 172 CBH measured by the first group. **Table 3** shows the results of biomass calculations. Values of the total aboveground biomass, each above ground component (i.e. foliage, stem, branches), and roots are presented. The total biomass was determined to be 8714 grams per square meter (g/m^2). Of that, 4357 g/m^2 can be attributed to carbon. Not surprisingly, students can see from the data that stems (i.e. tree trunks) account for most of the biomass (6798 g/m^2), but surprisingly, roots account for the second most (1855 g/m^2); followed by branches (1415 g/m^2), and lastly, foliage (i.e. the pine needles) (501 g/m^2). A GLOBE protocol that we did not conduct would have reminded students of the contribution that dead pine needles on the ground would make on biomass.

The second group of students selected a different site; one that had previously been identified as a mixed hardwood lowland forest. **Table 4** summarizes the process of determining that the MUC code of this site is 0211, meaning that the site was a closed, broad leaf/mixed hardwood lowland forest.

Table 5 lists the common names of the trees identified in the 15 m^2 study site and the circumference of each one. Students identified 4 sweet gums with CBH ranging from 12 cm to 112 cm; 7 hackberries with CBH ranging from 16 cm to 57; 1 sassafras at 31 cm; 7 magnolias with CBH ranging from 14.5 cm to 124.5 cm; and 5 oaks with CBH ranging from 8 cm to 125 cm.

Table 6 summarizes the calculations of biomass based on this data. Total biomass was determined to be 16,963 g/m^2 with 8481 g/m^2 attributed to carbon. Again, stems account for most of the biomass (12,882 g/m^2), roots second most (3469 g/m^2); followed by branches (3310 g/m^2), and lastly, foliage (770 g/m^2).

As students moved into later portions of the research portfolio, they were able to make specific connections between this data and studies performed by scientists in ecosystems around the world, and global environmental concerns. Instead of general claims of the effects of local biomass on the concern of global warming, students connected their own experiment to controlled burns in other ecosystems. For example, students connected the prescribed burning of the long leaf pine in Mississippi to the prescribed burning of long leaf pines in Montana (Peters, 2008). One student submitted "An Annotated Bibliography of Scientific Literature on Carbon Sequestration in Forests and Possible Implications of Forests in Reducing CO_2" which studied the potential of Mississippi pine forests as carbon sinks, and noted that the potential of these forests in reducing atmospheric carbon is overlooked in part due to Mississippi's struggling economy. The student noted that "*by raising awareness and value of these carbon reduction potentials, it is possible to further reduce CO_2 concentrations as well as provide the south with greater carbon based credits and environmental opportunities.*" While the student found several studies focusing on forestry in Mississippi, she was also able to connect her

Table 2.
Tree circumference data collected in the long-leaf pine controlled burn study site.

Species name	Tree circumference (CBH in cm)	Species name	Tree circumference (CBH in cm)
Pinus palustris	132.91	*Pinus palustris*	127.80
Pinus palustris	138.92	*Pinus palustris*	86.98
Pinus palustris	148.84	*Pinus palustris*	70.97
Pinus palustris	159.83	*Pinus palustris*	113.04
Pinus palustris	76.93	*Pinus palustris*	171.76
Pinus palustris	159.83		

Table 3.
Calculations of biomass based on data collected in the long-leaf pine controlled burn study site.

	Total above ground	Foliage	Stem	Branch	Roots
Plot biomass (kg/plot)	7843	451	6118	1274	1670
Biomass g/m^2	8714	501	6798	1415	1855
Carbon $g/\ m^2$	4357	250	3399	708	928

Table 4.
Summary of the questions used to determine the MUC code of the second study site.

Question	Answer	MUC Code	Conclusion
Is the site natural?	Yes		Natural (woodland, shrub-land, herbaceous, wetland or barren land).
Is more than 40% of the site covered by the canopy of trees that are at least 5 meters tall?	Yes		Trees (closed forest or woodland).
Are the crowns of the tees greater than 5 meters tall interlocking?	Yes	MUC 0	Closed.
Are at least 50% of the trees that reach the canopy evergreen?	No	MUC 02	Deciduous (87% deciduous, 10% evergreen).
Do the deciduous trees lose their leaves because there is a dry season?	Yes	MUC 021	Tropical and Subtropical Drought-Deciduous.
Is your site located in a lowland or submontane area?	Yes	MUC 0211	Closed, Mainly Deciduous, Tropical and Subtropical, Drought-Deciduous, Broad Leaved Lowland.

Table 5.
Common name and tree circumference data (CBH in cm) collected in the mixed hardwood lowland forest study site.

Common name/tree circumference (CBH in cm)		Common name/tree circumference (CBH in cm)	
Sweet gum	89.9	Magnolia	22.0
Sweet gum	12.0	Magnolia	40.3
Sweet gum	112.1	Magnolia	27.0
Sweet gum	33.0	Magnolia	124.5
Sassafras	31.0	Magnolia	29.0
Hackberry	24.5	Magnolia	23.0
Hackberry	43.4	Magnolia	14.5
Hackberry	53.5	Oak	41.5
Hackberry	56.0	Oak	8.0
Hackberry	57.0	Oak	69.0
Hackberry	17.0	Oak	120.0
Hackberry	16.0	Oak	125.2

Table 6.
Calculations of biomass based on data collected in the mixed hardwood lowland forest study site.

	Total above ground	Foli-age	Stem	Branch	Roots
Plot biomass (kg/plot)	3817	173	2899	745	781
Biomass g/m^2	16,963	770	12,882	3310	3469
Carbon g/m^2	8481	385	6441	1655	1735

research to related studies performed in Europe and Australia (Keith, 2009).

Other students were able to link their research on biomass and prescribed burning to its effects on other plants and animal life in the area. One student focused her efforts on the effect of prescribed burning on biodiversity, connecting prescribed burning efforts to restore sage-grouse habitats in Wyoming (Beck, 2009), efforts to restore vegetation and study bird response to burning efforts in the Ozark Glades (Comer, 2011), and the impact of prescribed burning on vegetation and birds in tallgrass prairies (Van Dyke, 2004).

Instead of focusing on local economic development, in the final portions of the research portfolio students were able to position themselves within a global community working toward understanding environmental problems. Using the GLOBE protocols in conjunction with a series of writing assignments allowed students to connect their work to research done in ecosystems throughout the world, and to specific environmental concerns such as carbon sequestration, biodiversity, and the impact of controlled burning on ecosystems.

Graduate Field Course for In-service Science Teachers

Methodology

A two-week long summer field biology course for secondary and post-secondary science and mathematics teachers was conducted at sites throughout Florida. Sixteen teachers and the first author spent several days at three sites: Manatee Springs, Everglades National Park, and Long Key State Park. In addition to time devoted to their individual investigations, the class collected land cover, soil, and hydrology data at each site. **Table 7** provides the list of equipment and materials used.

The class divided into three teams to collect the data, but team members rotated so that each person had the opportunity to conduct each type of protocol.

Located in northwest Florida, Manatee Springs flows into the Suwannee River which, in turn, flows into the Gulf of Mexico. The spring produces 81,000 gallons of freshwater every minute. The Manatee Springs area is surrounded by dry, sandy soil covered by a wooded canopy. Spanish moss hangs from red maple and sweet gum trees—wetland hardwoods that grow along river and stream beds. Air plants and resurrection ferns are found on the bald cypress trees. Upland hardwoods include oaks and southern magnolia, a broad-leafed evergreen tree. Two 15 m^2 study sites within the campground were surveyed. By definition, a campground is a disturbed area, and indeed, a heavy herbaceous layer showed evidence of high human impact. Therefore, the group rated the ecosystem as fair. The flood plain area, however, revealed very little human disturbance. The low herbaceous layer indicated an old growth forest and a healthy habitat. **Table 8** provides the data collected at this site.

The second camp site was in the Everglades National Park. Established in 1947, the park is composed of almost three million acres and spans the southern tip of the Florida peninsula. Elevation varies from a few feet below sea level to 8 feet above. The park has been designated a World Heritage Site, an International Biosphere Reserve, and a Wetland of International Importance. The only North American park considered a subtropical preserve, it is inhabited by both temperate and tropical plant communities including pine savannahs, hardwood hammocks, coastal prairie, and mangrove swamps. Hammocks, dome-shaped tree "islands" that grow on natural rises of only a few inches, are surrounded by marsh. These hammocks contain mangrove, cypress, pine, live oak, red maple, hackberry, mahogany, cocoplum, and gumbo limbo trees (one of the most wind-tolerant trees in South Florida and recommended as a hurricane-resistant species). The trunks of some trees were almost completely covered by the strangler fig and another epiphyte observed was the butterfly orchid. **Table 9** provides the data collected at this site.

At Long Key State Park, we surveyed a mangrove swamp. Numerous mud fiddler crabs were observed. These crabs dig

Table 7.
Materials used by the land, soil, and water quality teams.

Team	Materials
Land cover	50 meter tape Slap ruler Densiometer GPS unit Field guides
Soil	Auger Graduated cylinder Sodium hexmetaphosphate Munsell soil color chart LaMotte soil pH kit LaMotte surface lead test kit Soil organisms study kit
Hydrology	LaMotte water quality test kits: pH, DO, salinity Thermometer

Table 8.
Data collected by teachers at Manatee Springs State Park.

Data recorded	Observed organisms
July 16, 2006	Bald cypress
29˚, 29' and 19"N	Palm
82˚, 58' and 31"W	Gum
23' above sea level	Ash
# of satellites: 7	Maple tree
Water temperature: 71˚F	Apple snail
Salinity: 1 ppt	Red skimmer dragonfly
pH: 7.4	Fishing spider
DO: 2.0	Black vulture
Heavy metals:	Barred owl
0 ppb in springs,	Red shouldered hawk
50 ppb in sinkhole	Snail kite
200 ppb in river	Manatee
Soil sample taken 10 m from waters edge;	Sturgeon
10 cm horizon	White tailed deer
Soil pH: 7	Gray squirrel
Soil color: black, grayish brown, gray	Raccoon
Microbes present	
Soil Composition:	
10% sand, 21% silt, 69% clay	

Table 9.
Data collected by teachers at the Everglades National Park.

Data recorded	Observed organisms
July 17, 2006	Star grass
25˚48'43"N	Foliose lichen
80˚49'21"W	Butterfly orchid
3.9' above sea level at campsite	Mosquito
Natural max elevation 8'	Swallow tailed kite
Satellites: 7	Snowy Egret
Water temperature: 80˚F	Anhinga
Salinity: 0 ppt	Ibis
pH: 8.1	American alligator
DO: 2.75	Lubber grasshopper
Heavy metals: 150 ppb	Fishing spider
Soil sample taken 1 m from camp site; 10	Land hermit crab
cm horizon	Florida tree snail
Soil color: olive brown	Florida softshell turtle
No microbes present	Oppossum
Soil pH: 7	
Shallow soil layer over limestone	
Soil composition:	
22% sand, 11% silt, 60% clay	

burrows in mangrove stands and mudflats that can be up to three feet deep, and usually end in a "room" which they occupy during high tide. Fiddler crabs serve as a food source for blue crab, birds, and raccoons, but also play important roles in marsh processes. Their burrowing and feeding affect the aeration, and hence the growth of marsh grasses. They stimulate the turnover and mineralization of important nutrients. They are also a good environmental indicator and sensitive to contaminants, especially insecticides. Their population densities are an example of the high productivity of wetlands and the health of this ecosystem in particular. In addition, the absence of an herbaceous layer indicated a healthy ecosystem at this site. **Table 10** provides the data collected at this site.

Results

A follow-up study was conducted to seek evidence for classroom transfer. Was teacher efficacy in conducting field studies increased sufficiently for their students to experience field studies during the school year? Data was collected via a nine-item

Table 10.
Data collected by teachers at Long Key State Park.

Data recorded	Observed organisms
July 20, 2006	Spider lily
24˚, 48' and 43"N	Red mangrove
80˚, 49' and 21"W	Black mangrove
3' above sea level	White mangrove
Water temperature: 80˚F	Blue heron
Salinity: 36 ppt	Great egret
pH: 8.2	Cormorant
DO: 5.6	Brown pelican
Heavy metals: 300 ppb	Sea urchin
Soil sample taken 20 meters from	Mosquito
waters' edge; 10 cm horizon	Sand fiddler crab
Soil color: light gray, pinkish white	
with crushed coral	
No microbes present	
Soil pH: 8	
Soil Composition:	
28% sand, 6% silt, 66% clay	

anonymous survey sent after the subsequent school year. Eight teachers responded (a 50% response rate). The first three questions collected discreet data:

- About how many field-based lessons or activities did you use in your classroom that you experienced during the field course?
- About how many times did you take students outside during the school day in order for them to conduct authentic research?
- About how many times did you organize a field trip beyond the school day for them to make observations in nature or collect data?

All but two teachers reported using field-based lessons or activities experienced during the field course in their classes the following year. One reported using 7 - 8 lessons or activities, but the mode (3 teachers) was 3 - 4. Six teachers reported taking their students outside during the school day in order for them to conduct authentic research. One reported taking students outside 5 - 6 times, but the mode (4 teachers) was 3 - 4. Only one teacher organized a field trip that extended beyond the school day in order for his or her students to make observations in nature or collect data. **Figure 2** shows the data in graphical form. A list of the lessons reported as being used by teachers the following year is provided in **Table 11**.

The survey included four open-response items. These included:

1) What were the impediments you faced in implementing any of these activities?

2) How did your understanding about science or appreciation of science change as a result of participating in the field course?

3) What experience(s) in the field course did you find most (4. least) valuable? Why?

In response to question number 1, almost all teachers reported the typical and expected impediments: time constraints; class periods too short for outside activities; uncooperative colleagues; and unwilling superintendents either due to testing or liability issues. Sadly, one teacher tried very hard, but eventually was prevented from taking students on a field trip:

We had a field trip planned to an alligator farm to coincide with an interdisciplinary unit on the Everglades. Our Reading teacher and I collaborated to have the students read "The Missing Gator of Gumbo Limbo" as we studied the Everglades

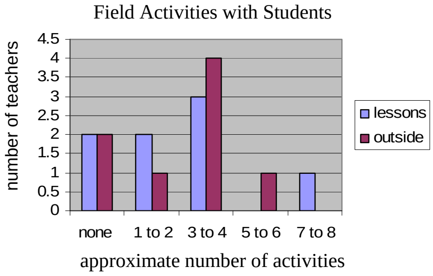

Figure 2.
Field lessons conducted with students the following year as reported by teachers.

Table 11.
Field lessons or activities used during the following school year as reported by teachers.

Biosphere in a bottle	Insect ecology
Using dichotomous keys	Campus ecology
Water-testing techniques	Chromatography with local plants
Collecting microorganisms	Leaf collection and identification
Developing observation skills	Identifying organisms

in my 7th grade science classes. The trip was cancelled by the School Board due to safety concerns.

Only one teacher stated that keeping students on task was a major impediment to conducting field activities. In response to question number 2, one teacher stated that the field course simply affirmed his or her understanding or appreciation of science. Most responses, however, fell into two categories. One teacher gave responses that included both categories. Representing one category, five teachers thought that being able to transmit first-hand knowledge of the ecosystems in Florida to their students helped them be more effective teachers. A response of this nature included:

The individual research topics led to a greater understanding of data collection and record keeping that I now share with my students. As a result, my students are more able to develop their own research area and communicate their findings with greater ease.

Representative of the second category, four teachers spoke of a better understanding of ecology as a science because of the field course. Two such responses follow:

(*I have*) *more understanding about the interrelationships of animals in a habitat, especially in the Everglades. I now see the alligator as not only a predator but as behaviorally the reason the Everglades work as they do as a habitat and migration sanctuary for such a diversity of animals.*

The main change that I had was concerning the amazing work being done in Florida on conservation efforts for all of the sites that we visited. Often we only hear of the problems without much mention of the scientific creativity involved in solving them.

Each teacher gave detailed responses to question number 3. One noted that snorkeling in the Dry Tortugas was the most valuable experience in the field course. Two teachers reported that the opportunity to work both independently and cooperatively was the most valuable experience. Another referred to this indirectly when providing this response:

The most valuable to me was watching our instructor keep us focused, while allowing us to organize and carry out our field study work. I have often failed at getting the point across to high school students when collecting and analyzing data from field work.

The remaining four stated that the opportunity to actually experience nature and conduct field studies was the most valuable experience. One such response follows:

I feel the hands-on experiments we conducted as well as the "*up close and personal*" *experiences with the wildlife and plant life enabled me to bring those experiences—along with a renewed enthusiasm to my classroom* […] *these experiences will help me to be more comfortable conducting similar activities with my students.*

In response to the final question, seven of the eight respondents stated that there were no invaluable experiences. However, one teacher talked about the group report as the least valuable experience:

I don't recall any wasted moments except a tiny bit of frustration when making a group report on our findings. But hey, this was still very valuable in learning to cope!

Conclusion

Both students and teachers demonstrated enthusiasm and enhanced understandings of the nature of science during their field trips. For the Writing in the Sciences class, students accommodated their research for a variety of audiences, showing how local environmental concerns impact the immediate community, but also connecting their research to environmental problems around the globe. In all classes, GLOBE participants demonstrated increased knowledge of ecology, natural histories of various organisms, and awareness of environmental resources. For the teacher in-service class, a study conducted the following summer revealed that teachers valued the course and felt that their experiences helped them be more effective teachers. Six of the eight teachers conducted field activities with their students the following year, but also reported significant challenges associated with the effort. In the current environment of high-stakes testing, the time and effort required to conduct field studies is often used to justify the absence of authentic field-based learning. At the same time, critical environmental issues are finally being recognized across the nation. The GLOBE program is a resource that enables students to investigate their local environmental, while situating their experience within a global network of research.

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