Implementing Higher Education Partnerships: Enhancing Inquiry-Based Science Education at Multiple Levels

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Abstract

Responsibilities for "Science Education" in higher education settings typically involve separate Colleges of Education and Arts & Sciences. Cooperation between these elements may range from excellent to marginal. A GLOBE Partnership can serve as an outstanding tool to energize cooperation and enhance collaboration. The GLOBE Teacher Training Partnership at the University of West Georgia has developed inquiry-based, hands-on Science Education "content" courses at multiple levels. Science faculty from the College of Arts and Sciences and Science Education faculty from the College of Education have worked together to create three courses focused on the needs of Early Childhood, Middle Grades, and Secondary Science majors, for both pre-service and in-service teachers. Each course has a laboratory component involving GLOBE protocols and learning activities that are tied to state standards at appropriate grade levels, as well as inquiry-focused projects that involve data gathering, analysis, reporting, and presentations using GLOBE guidelines. Course objectives, learning goals and format will be presented for these courses, along with examples of projects and assessment. In addition to creating quality courses, quality partnerships have also been facilitated among faculty in different Science Departments and between faculty in the two Colleges. Pre-service and in-service teachers also get the opportunity to form partnerships with Science Department and Science Education faculty from both Colleges, who can serve as future mentors and research partners, and who can provide access to data and resources beyond the capabilities of many K-12 schools. This presentation will also highlight access to free Earth Observations satellite imagery and teaching resources available through an academic consortium in partnership with the GLOBE Program - the AmericaView Consortium.

Background

The responsibilities for serving K-12 science education majors at the University of West Georgia (UWG) are shared between the College of Education (COE) and the College of Arts and Sciences (CAS). The COE faculty focus on demonstrating and observing science teaching methods within a standards-based, content-rich context, while the CAS faculty focus on teaching science content in courses that combine lecture-based content classes and hands-on, inquiry-based laboratories. Each College is involved in teacher education at multiple levels, including undergraduate K-12 teacher preparation, Masters-level education for in-service teachers, and professional development for in-service teachers. Course development has typically been carried out within the Colleges essentially independently of one another; even development of an "Integrated Science" course within the CAS has not involved faculty from different Departments working together.

Environmental Observations

Several years ago, the faculty involved began to come together to enhance cooperation in teacher education course development. The Department of Geosciences on the CAS established a position focused on improving Earth System Science (ESS) content education, and the faculty member who filled that position chose to establish a pre-service GLOBE Partnership at UWG. Efforts to involve a new COE Science Education specialist were successful. The dual goals of establishing the GLOBE Partnership were to bring ESS and GLOBE to both the predominantly Early Childhood Education pre-service majors at the University of West Georgia, and to the in-service graduate-level teachers returning for Masters degrees in Science Education.

The first new course developed was "Environmental Observations", a three-hour lecture/two-hour lab, freshman-level course in the CAS that Early Childhood Education majors were advised to choose as their required science-with-lab course within the Core. This ESS/GLOBE-based course was designed and taught by both the Geoscience faculty member from CAS and the Science Educator from COE. The "hook" from the perspective of both Colleges was the ability of GLOBE to enhance an inquiry focus with hands-on field and laboratory experiences that combine content and pedagogy, which are tied to national standards that are the basis for Georgia's K-12 standards. The success of "Environmental Observations" at the pre-service level led to the development of a graduate-level Geoscience course for in-service teachers, including those attending graduate school at UWG and those interested in the course for professional development. The summer course "Earth Science for Teachers" was designed to cover ESS content for in-service 6th grade Earth Science teachers during class periods, and to introduce GLOBE Learning Activities and Protocols directly tied to Georgia Performance Standards during hands-on laboratory sessions. The success of "Environmental Observations" also highlighted the potential for cooperation between the Colleges in course development, and contributed to the redesign of an existing "Integrated Science" course for Early Childhood Education majors. Originally a one-semester course covering Chemistry, Physics, Biology, and Earth

Science, this course is now a two-semester required sequence for all Early Childhood Education majors. One of the courses combines Life and Earth Sciences, and its laboratory sessions involve ESS-based GLOBE Activities and Protocols that tie together the two disciplines. Geoscience and Biology faculty have worked with COE Science Education faculty to redesign this course, emphasizing inquiry, modeling science education across the curriculum, and relating activities to Georgia Performance Standards.

Course objectives, goals and format

"Environmental Observations" is taught during the Fall and Spring semesters; course objectives include:

- To understand the earth as a system in which the hydrosphere, biosphere, lithosphere, and atmosphere interact to create our environment;
- To understand the relationships among the earth's four spheres and how they affect one another;
- To make and analyze environmental observations using sound scientific protocols, scientific inquiry methods and perspectives;
- To plan and implement standards-based student inquiry projects concerning the Earth System;
- To use online visualization technology to map, graph, and analyze global environmental data.

The course comprises three one-hour classroom sessions each week, and one two-hour laboratory session. The classroom sessions involve lectures, content reviews and testing. Assignments include a "classroom infusion project" in which students work alone or in groups to design a bulletin board or other visual display for a grade-level specific classroom and standard(s) concerning the Earth System, GLOBE observations protocols, or GLOBE learning activities. This project can be designed to teach an Earth System science concept or to promote observational skills. This visual product is presented to the class. Students must also design a grade-level specific, standards-based "student inquiry project" with data gathered using GLOBE protocols learned in lab, data from the GLOBE archive, or other GLOBE resource materials that would enable them to address performance standards for a specific grade level. Students are provided with appropriate performance standards for their chosen grade level and with instructions concerning successful student investigations provided by GLOBE ("student investigations" at http://globe.gov/fsl/investigations/IndexReports.pl). Students must submit their original research problem/ question/hypothesis for review, and must submit their project design for approval. A report must be submitted using the suggested GLOBE Student Research Report format (http://globe.gov/fsl/investigations/sj-investig.html).

Sample Student Inquiry Projects

Standard: Students will recognize the effects of pollution on the environment (**3rd grade** Georgia Performance Standard for Life Science #2; http://www.georgiastandards.org/)

Question: How does pollution that results in acid rainfall influence the environment?
Hypothesis: Acid rain will damage plant leaves and increase soil pH, killing plants.

Review of proposed project:
Is this grade-level appropriate? Discussed experimental design problems concerning measurement of soil pH and understanding of concept for 3rd-grade level students.

Revised hypothesis: Acid rain will damage plant leaves and slow plant growth.

Experimental Design:
5 identical plants
5 concentrations of water/vinegar in spray bottles (pure water; 25% vinegar; 50% vinegar; 75% vinegar; 100% vinegar)
Spray twice a week for four weeks, until leaves are covered with water and spray drips off leaves, soaking soil surface.
Photograph plants once a week.
Chart plant growth
Report using designated format

Standard: Students will differentiate between the states of water and how they relate to the water cycle and weather. (**4th grade** Georgia Performance Standard for Earth Science #3; http://www.georgiastandards.org/)

Observation/Question: When I shower in the winter, water condenses on the windows in the bathroom. The bedroom windows are dry. Why are the windows in the bathroom dripping?

Hypothesis: In both rooms, the air near the windows is colder than the air in the rest of the room because of cold air outside, and the humidity eventually reaches 100% inside the bathroom while the shower is on. This allows condensation where the air is cooled by the cold windows.

Experimental Design:

Measure outside temperature
Measure inside temperature in both rooms
Measure inside relative humidity in both rooms
Turn on shower and measure relative humidity at 4-minute intervals until condensation begins on windows.
Chart results
Report using designated format

Current Events Collection

During each week of the class, beginning with week one, students are required to find an article about the environment from a **current, printed** newspaper or magazine and write a brief (2-paragraph) synopsis of the article, highlighting its Earth Systems connections. The articles and the synopses are pasted into a notebook for submission. The print media requirement is designed to discourage "googling" by key word, and to encourage actually reading the news.

Students in "Environmental Observations" are also required to keep a "current events collection" and a "science journal". The current events collection is a weekly exercise outside of class that requires student to find an article about the environment from a **current, printed** newspaper or magazine and write a brief (2-paragraph) synopsis of the article, highlighting its Earth Systems connections. The print media requirement is designed to discourage "googling" by key word, and to encourage actually reading the news. These articles are open for discussion at the beginning of each class period, and the articles and the synopses are pasted into a notebook for submission at the end of the course.

The science journal is part of the laboratory assignments, but includes materials and concepts introduced in the classroom. Students keep a weekly reflective journal in which they record introductory science content notes concerning lab activities, as well as observations in these content areas that they make outside of class. They are instructed to ask and record questions and hypotheses they develop concerning their observations, so that the Journal can be a source of ideas for their student inquiry project. These Journals are open for discussion during the laboratory or during the classroom period.

Journal Observations Example

Tonight's observation is quite an interesting one. It's about 11:00 p.m. and I am at a campout and it is very cold. The temperature is about thirty five degrees or so. Me (sic) and a couple of my buddies got the great idea of starting a fire. Well my question is "what is the temperature change when you are five feet away from the fire (like the area where everyone was standing), opposed to being 10 feet from the fire? Well I had a thermometer in my truck and measured the temperature 5 feet from the fire and 10 feet from the fire. The temperature 5 feet from the fire was eighty-three degrees and the temperature 10 feet from the fire was a shocking fifty-three degrees! Wow, that's over a 30 degree temperature change, just in a matter of five feet. And by the way, my buddies were not aware of my experiment, I'm sure I would have gotten an earful.

Earth Science for Teachers

"Earth Science for Teachers" is targeted for in-service 6th-grade Earth Science teachers in Georgia and is taught over a four-week period during the summer. Classes meet each day for 3 hours. Course objectives include

- To introduce Earth System Science topics across all 6th-grade Earth Science Georgia Performance Standards' co-requisite "content" and "characteristics of science" standards;
- To provide resources for Middle-grades Earth Science Teachers to use in teaching Earth Science;
- To develop hands-on data-gathering and analysis experience using scientific protocols and tools;
- To introduce the GLOBE Environmental Education Program and certify teachers in GLOBE.

Georgia Performance Standards 6th grade Earth Science learning goals for content specifically targeted in this course include developing abilities to

- Explore current and historical scientific views of the Universe and the solar system.
- Understand the effects of the relative positions of the earth, moon and sun.
- Recognize the significant role of water in earth processes.
- Understand how the distribution of land and oceans affects climate and weather.
- Investigate the scientific view of how the earth's surface is formed.
- Describe various sources of energy and with their uses and conservation.

Georgia Performance Standards learning goals for the 6th grade Earth Science "Characteristics of Science" specifically targeted in this course include

- Students will use standard safety practices for all classroom laboratory and field investigations.
- Students will use computation and estimation skills necessary for analyzing data and following scientific explanations.
- Students will use tools and instruments for observing, measuring, and manipulating equipment and materials in scientific activities.
- Students will use the ideas of system, model, change, and scale in exploring scientific and technological matters.
- Students will communicate scientific ideas and activities clearly.
- Students will investigate the features of the process of scientific inquiry.

Soil, hydrology, and atmosphere investigations within the GLOBE program provide ideal Protocols and Learning Activities to teach both content and characteristics of science in a 6th grade Earth Science classroom. Content is emphasized during lectures and discussions, reviews, and a test during the first week of class. The second week of class involves online activities and exercises associated with the interactive textbook "Applications and Investigations in Earth Science" (Tarbuck, Lutgens, and Pinzke; http://wps.prenhall.com/esm_tarbuck_appinvest_4) as well as exploration for classroom resources across all content areas including online resources such as the Digital Library for Earth Systems Education (http://www.dlese.org/library/index.jsp) and the GLOBE Teacher's Guide Content Search resource (http://www.globe.gov/tctg/conceptsearch.jsp). During this second week teachers find a "sample task" that will address a specific Georgia Performance Standard. They begin to prepare a presentation in which they will introduce the task to the class, tie it to the learning goals of the Standard, and explain how they will assess student learning following implementation of the task.

The third week of class involves GLOBE Protocols and Learning activities within the soils, hydrology, phenology, and atmosphere investigation areas.

WEEK THREE LABORATORY ACTIVITIES
GLOBE learning activities and protocols tied to the Georgia Performance Standards for Sixth Grade Earth Science (http://www.georgiastandards.org/).

GLOBE links are from the GLOBE teacher's guide table of contents http://www.globe.gov/tctg/tgtoc.jsp on the GLOBE web site http://www.globe.gov/

S6E2. Students will understand the effects of the relative positions of the earth, moon, and sun.
c. Relate the tilt of the earth to the distribution of sunlight throughout the year and its effect on climate.

- ***GLOBE EARTH SYSTEM POSTER ACTIVITIES***
  - ***http://archive.globe.gov/wist/earthsysposter.jsp interactive poster***
  - ***http://www.globe.gov/fsl/pdf/posterla.pdf activities***
- ***GLOBE making a sundial Learning Activity***

    - ***http://www.globe.gov/tctg/atla-sundial.pdf?sectionId=22***
- ***GLOBE Modeling the Reasons for Seasonal Change Learning activity***
    - ***http://www.globe.gov/tctg/earth_la_seaphen_s4.pdf?sectionId=259***
- ***GLOBE How do Seasonal Temperature Patterns Vary among Different Regions of the World?***
    - ***http://www.globe.gov/tctg/earth_la_seaphen_s3.pdf?sectionId=258***

S6E3. Students will recognize the significant role of water in earth processes.

b. Relate various atmospheric conditions to stages of the water cycle.

c. Identify the major types of clouds (cumulus, cirrus, stratus, nimbus, etc.) Keep a weather journal for a period of time of observations of sky conditions listing the type of cloud and the weather conditions. Look for relationships and explain how major cloud types associate with the movement of fronts and the resulting weather.

- ***GLOBE Cloud protocol online teaching module http://gpdi.globe.gov/advance/***
- ***GLOBE hydrology intro http://www.globe.gov/tctg/hydro_chapintro.pdf?sectionId=145 (content info)***
- ***GLOBE Atmosphere intro http://www.globe.gov/tctg/atmintro.pdf?sectionId=4 (content info)***
- ***CLOUD COVER http://www.globe.gov/tctg/clouds.pdf?sectionId=8***
- ***OBSERVING, DESCRIBING, AND IDENTIFYING CLOUDS http://www.globe.gov/tctg/atla-idclouds.pdf?sectionId=19***
- ***GLOBE CLOUD QUIZ (ONLINE) http://www.globe.gov/sda-bin/m2h?gl/clouds.men***
- ***ESTIMATING CLOUD PROTOCOLS http://www.globe.gov/tctg/atla-cloudcover.pdf?sectionId=20***

d. Explain how weather is composed of air temperature, humidity, wind speed and direction, and precipitation in a particular place and time.

- ***RELATIVE HUMIDITY PROTOCOL http://www.globe.gov/tctg/relhum.pdf?sectionId=11***
- ***GRAPHING CLOUD COVER, PRECIPITATION, RELATIVE HUMIDITY, BAROMETRIC PRESSURE http://viz.globe.gov/viz-bin/show.cgi?l=en&b=g&rg=n&enc=00&nav=1&page=help-tut_intro.ht***
- ***ESTABLISHING AN ATMOSPHERE SITE http://www.globe.gov/tctg/atinst.pdf?sectionId=7***

e. Illustrate the movement of water through the water cycle, showing that it is a solvent moving minerals and gases along to the oceans.

- ***DISSOLVED OXYGEN http://www.globe.gov/tctg/hydro_prot_do.pdf?sectionId=151***
- ***ELECTRICAL CONDUCTIVITY http://www.globe.gov/tctg/hydro_prot_conductivity.pdf?sectionId=153***
- ***Ph http://www.globe.gov/tctg/hydro_prot_ph.pdf?sectionId=152***
- ***WATER TEMPERATURE http://www.globe.gov/tctg/hydro_prot_temp.pdf?sectionId=150 includes THERMOMETER CALIBRATION)***

S6E4. Students will understand how the distribution of land and oceans affects climate and weather.

a. Demonstrate that land and water absorb and lose heat at different rates and explain the resulting effects on weather patterns.
b. Relate unequal heating of land and water surfaces to form large global wind systems and weather events such as tornados and thunderstorms.
c. Relate how moisture evaporating from the oceans affects the weather patterns and weather events such as hurricanes.

Sample Tasks:

c. Compare temperatures in the sunshine with temperatures in the shade. Compare temperatures at different heights above the ground. Compare temperatures above grassy surfaces with temperatures above paved surfaces. Compare temperatures on the north, east, south, and west sides of a building at different times of the day. Analyze the data and conclude about unequal heating and cooling of surfaces.

- ***STUDYING THE INSTRUMENT SHELTER http://www.globe.gov/tctg/atla-shelter.pdf?sectionId=24***

S6E5. Students will investigate the scientific view of how the earth's surface is formed.

g. Describe soil as consisting of weathered rocks and decomposed organic material.

- ***SOIL INTRO*** ***http://www.globe.gov/tctg/soil_intro.pdf?sectionId=88***
- ***SOIL CHARACTERIZATION*** ***http://www.globe.gov/tctg/soilchar.pdf?sectionId=91***
- ***JUST PASSING THROUGH*** ***http://www.globe.gov/tctg/passthrough.pdf?sectionId=102***
  http://www.globe.gov/tctg/passthrough_beg.pdf?sectionId=101 ***(BEGINNERS VERSION)***

In addition to practicing the protocols in the laboratory and outside at sample sites, students establish observation sites, enter data and access the GLOBE archives to create maps and graphs. For each laboratory session, teachers maintain a Lab Assessment Journal in which they comment on whether or not the Protocols and Learning Activities are grade-level appropriate and useful in addressing the learning goals of particular Standards, and whether they could be used as a jumping-off point for extended inquiry (such as science projects).

Lab Assessment Journal Examples

My students would LOVE moving to a site where they determined calculations such as temperature, pH, and turbidity of water. It isn't often that students are allowed to perform hands-on activities outside of the classroom, and I believe they would appreciate the opportunity.

My students would love looking at other schools' data and converting these into charts and graphs. This is also a skill that students need to sharpen. They would love knowing that their experiments were being used in some way. They would also enjoy seeing that other students were performing the same experiments they were performing. Globe makes it easier for teachers to answer the never ending questions, "Why are we studying this?" or "When will we ever use this?"

During the fourth week of class teachers discuss their laboratory assessments and share ideas about classroom applications. They also present and discuss their "sample task" selections.

Integrated Science – Life/Earth Sciences

The Georgia University System Board of Regents recently mandated that all Early Childhood Education majors are required to take two integrated science content courses; one covers physics and chemistry, while the other covers earth science and biology. Each College and University in Georgia that prepares teachers was provided with specific learning outcomes and each has designed its own courses. At the University of West Georgia, the class will comprise two one-hour content lecture sessions per week, and one two-hour laboratory session per week. The Life/Earth Science class segues from one content topic to the other with an Earth Systems perspective that ties together Ecosystems with Earth's atmosphere, hydrosphere, and lithosphere. The laboratory sessions involve GLOBE activities applied to environmental observations in the atmosphere, hydrology, soils, land cover, and phenology protocol areas. Pre-lab assignments are focused on guided inquiry using GLOBE data, leading to in-lab small group activities that include sampling design, comparison of results, and presentation of results. This course has been designed and will be taught for the first time on the University of West Georgia in the Spring semester of 2008.

The University of West Georgia has developed inquiry-based, earth systems-focused courses at multiple levels, involving partnership between faculty in the Colleges of Education and Arts and Sciences. The standards-based science content needs of both undergraduate and graduate Education majors have been identified and addressed, as have the professional development needs of local in-service teachers. Faculty from both colleges have been trained in the GLOBE Environmental/Earth Systems Science program, which emphasizes science with an inquiry focus, built around hands-on activities that combine content and pedagogy. The partnership across college boundaries and within the CAS has also engendered new professional development for local in-service teachers, bringing together diverse disciplines for outreach and to seek funding opportunities. It has led to the development of new mentoring relationships both between faculty across Colleges and between faculty and teachers. It has also given teachers access to resources from funded programs on campus that would otherwise be beyond their budgetary means.

The University of West Georgia is working with local school districts to develop environmental change detection data sets based on satellite imagery, in order to enhance Earth Science and Environmental Science curricula at Middle and High School levels. Purchase of multi-year satellite imagery is being funded by the AmericaView[SM] Consortium (AmericaView; http://www.americaview.org/). AmericaView is a non-profit educational consortium active in 30 states whose goal is to promote applications of satellite imagery in addressing our nation's problems, including environmental change. Thirty StateView academic consortia are all involved in educational outreach to K-12 teachers and students to bring satellite imagery into classrooms, often in affiliation with GLOBE Partnerships. AmericaView's national and state-level activities are currently focused on implementing an education and awareness effort called Earth Observation Day, which will take place October 19, 2007, during Earth Science Week. Remote Sensing observations of Earth resources including surface materials/land cover, freshwater and marine ecosystems, and the atmosphere provide teachers with the data needed for inquiry based, Earth systems focused learning in the disciplines of Earth Science, Chemistry, Physics, Biology, and Geography. AmericaView proposes to develop a focused set of activities that target specific standards and learning outcomes in the Science and Geography disciplines, while developing interdisciplinary activities designed to connect remote sensing to mathematics, social studies, and creative disciplines including writing and the arts. AmericaView will work through partner academic consortia to implement and support local, regional and global remote sensing activities during Earth Observation Day (http://www.americaview.org/AGI_Flier.pdf).

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