Place-Based Environmental Science Training in the Rural Mississippi Delta

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Abstract

The rural Mississippi Delta is a high poverty agricultural region that is a critical needs area for science education. Schools are poor, with little ability to attract and retain highly qualified teachers. To address the high regional needs, we implemented a three-pronged approach that included building and strengthening community partnerships; targeting professional development in response to the needs of science teachers; and making the science curriculum relevant by connecting the environment and environmental issues of importance in the region. Delta State University science faculty developed a two-week interdisciplinary course for middle school science teachers, immersing them in place-based learning on the chemistry, biology, microbiology, botany, and geology of aquatic food webs in the region. Twenty-one middle school teachers from 18 regional high-needs schools took part. Following the workshop, participating teachers continue to receive support including additional training and resources. The participants reported positive impacts in classroom teaching as a direct result of the partnerships, training, and on-going support.

Keywords: place-based education, Mississippi Delta, aquatic food webs, middle school, rural

Place-Based Environmental Science Training in the Rural Mississippi Delta

Mississippi is the nation’s number one priority for rural education (Strange, Johnson, Showalter, & Klein, 2012). This region serves a mostly minority population and struggles with high poverty and failing school districts. Fifty-five percent of Mississippi students live in rural areas and 63% of those live in poverty. No other state serves as many rural students as does Mississippi (Strange, et al., 2012). Poverty level strongly correlates with standardized test scores, and this is painfully evident in the Delta region (Fitts, 2014). Education in the areas of science, technology, engineering, and mathematics (STEM) is a critical needs area for science education (Mississippi Department of Education, 2010). Even though Mississippi has made significant gains in the last twenty years, it continues to lag behind all other states and Washington, D.C., ranking 51st in 8th grade reading and math (Kena et al., 2014).

Delta State University is a rural, regional university with a mission to meet the educational needs of the region. The overwhelming magnitude of problems in this area has contributed to a cocooning of the university rather than a deepening relationship with the regional educational stakeholders. Analysis of the literature on successful rural, high poverty schools led to the development of a three-pronged framework (Figure 1) as the basis of holistically addressing the science education needs of the Mississippi Delta (Fitts, 2014). The framework’s components consisted of building community partnerships between university faculty and local science teachers, developing targeted professional development activities in response to the needs of these science teachers, and developing regionally contextualized science lesson plans aligned with both state science and Common Core standards.

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Environmental Science is prominently featured throughout the Mississippi Science Curriculum Frameworks (MSCF, 2014), which are composed of Inquiry, Life Science, Physical Science, and Earth & Space Science. Even though direct experiences with nature enhance environmental awareness and play a crucial role in shaping adult environmental behavior (Bogner, 1998; Palmer & Suggate, 1996), many residents lack exposure and understanding of environmental science concepts. This lack of understanding fosters an anthropocentric attitude that leads to degradation, reduction, and fragmentation of natural habitats (Chivian, 2001).

Place-based education (PBE) is environmental science education framed in the context of the local environment. In PBE, students use environmental issues from their communities as the basis for scientific investigation. In rural regions predicted to have low environmental science performance, place-based education helps contribute to improved performance (Aldous, 2008; Bang & Medin, 2010; Leslie, 2001; Semken, & Freeman, 2008). Place-based education has been successful in rural communities around the world, resulting in increased levels of engagement, promoting authentic inquiry, and facilitating the survival of rural communities (Howley, Howley, Campter, & Perko, 2011; Hume & Coll, 2010; Tytler, Symington, Kirkwood, & Malcolm, 2008).
Land use in the rural MS Delta region is over 80% agricultural, and many opportunities exist for PBE, particularly in impoverished areas such as the Mississippi Delta.

Using the three-pronged conceptual framework, science faculty developed a two-week, interdisciplinary pilot-study course taught in a workshop format with the objectives to:

1) Improve environmental science teaching skills through field exercises and enhanced content knowledge,
2) Provide resources for area science classrooms,
3) Increase student knowledge and interest of basic concepts and methods of understanding local environmental issues, and
4) Promote environmental science as a course of study and career choice.

Following the pilot study, teachers continued to receive guidance by attending other workshops provided on weekends by Delta State University (DSU) faculty that further emphasized topics regarding specific environmental issues.

The goals of the pilot study workshop addressed specific components of all four strands of the Mississippi Science Curriculum Frameworks at the middle school level: Inquiry, Physical Science, Life Science, and Earth & Space Science. Instructors emphasized environmental issues pertaining to aquatic food webs: water chemistry, vertebrate and invertebrate sampling and recognition, parasites, microbes, invasive and native plants, vermicomposting, teaching with community gardens, connecting lessons to Common Core frameworks, and Mississippi River geology. DSU science faculty and the regional Adopt-a-Stream coordinator from the Mississippi Wildlife Federation taught the sessions. A field trip to the regional Agricultural Research Service of the United States Department of Agriculture (USDA-ARS) catfish facility in Stoneville, MS allowed teachers to experience active science research occurring in the community. Delta State University office of Continuing Education gave each participant seven Continuing Education Unit (CEU) credits. Teachers also received stipends, equipment, books, and funds to purchase additional materials for their classrooms. The project coordinator developed a wiki to allow participants to access presentations, notes, handouts, and other resources during and after the two-week workshop. Following the workshop, teachers continued to communicate with each other, ask questions, and post experiences and pictures relating to activities they incorporated into their classroom curriculum via the wiki.

Materials and Methods

Initial Screening

Teachers wrote brief essays about what they hoped to gain from their participation in the course. Instructors used these responses to determine teacher expectations. Selected teachers completed a brief survey that assessed their perceived knowledge of workshop topics and their demographics. The twenty-one teachers participating were from 18 rural, ‘high-need’ middle schools across the Mississippi Delta region. Only one-third of the predominantly female participants reported majoring in a field of science or secondary science education. Years of teaching experience varied greatly. One-fourth were classified as novice teachers (1 to 3 years’
experience), half were experienced (4 to 20 years), and one-fourth were very experienced (>20 years of experience). Most participants did not use field trips for science instruction (71%), but held weekly or bi-weekly laboratory experiences, and expressed they had adequate school laboratory facilities (90%). All participants, however, expressed a need for resources and lessons aligned with the curriculum frameworks. In the initial survey, participating science teachers mentioned that their greatest needs were obtaining high quality training in science instruction acquiring money for supplies and increasing student/parent interest in learning science.

**Teacher Expectations**

Teachers entered the program with a variety of self-determined learning goals. An analysis of the learning goals revealed that teachers wanted to learn about implementation of Common Core State Standards, find ways to engage students, add hands-on cost-effective activities, learn about regional plant/animal life, and raise test scores. Most (44%) reported a desire to learn engaging activities or laboratory exercises they could take to their classrooms. The desire to gain science content knowledge was the second most common theme, with 16% of participants alluding to this desire in their responses. Three out of 21 reported a desire to learn how to connect science instruction to the Common Core as a primary reason for participating. Other themes identified (Figure 2) from the analysis of participating teachers’ goals included integration of technology and science, more effective teaching strategies, networking with other science teachers, and earning CEU credits. One teacher commented:

*I hope to show students that there is more to the water in our ditches, streams and lakes by being able to analyze a sample to see what’s going on and what’s living in it as well; to show students that the delta plant life is unique and valuable to our community.*

![Figure 2: Teachers’ self-reported greatest needs.](image)

**Individual Session Evaluation**

Participants evaluated each of the ten sessions at its conclusion using a common evaluation form. They ranked the overall experience of the session, the usefulness of the materials and hands-on activities, the appropriateness of the level of instruction, and the
presentation style of the presenting faculty member. Open-ended questions allowed teachers to indicate what they learned and were most likely to try in their classrooms, and to provide suggestions for improvement.

Post-workshop Survey and Follow up

Participants completed a post-workshop exit survey at the end of the two-weeks. They ranked the course and session experiences on a scale from Not Useful to Excellent. The exit survey asked open-ended questions about how the course helped expand and improve environmental science knowledge and attitudes, and how they would implement what they learned to improve student knowledge and interest in aquatic food webs and local environmental issues. They identified additional support, resources, and training that would help them incorporate what they learned into their classrooms.

Because all participants indicated low initial knowledge on the recurrent, interdisciplinary topic of eutrophication, assessments of their knowledge and understanding of the concept served as a primary measure of participant learning. To assess their understanding of this concept, teachers defined eutrophication in their own words, and their responses qualitatively analyzed in comparison to a standard accepted definition.

Content Covered in Interdisciplinary Sessions

The organizers taught the course over a two-week interval and divided it into ten individual seven-hour sessions. The sessions covered a wide range of topics taught by very diverse faculty and community members. Each session provided handouts, online resources, laboratory instructions, and other relevant materials via a shared wiki page following the course.

Gardens and Vermicomposting

Teachers explored the use of school gardens for hands-on student inquiry; only three of the eighteen schools represented already had access to established school gardens. Teachers explored the organic DSU community garden and developed ideas for engaging students in experimental learning. They learned how to establish a vermicomposting bin in the classroom, and examined the food webs present in a well-established worm bin. Using the worm bins, teachers identified worm cocoons, decomposed materials, and a number of other invertebrate decomposers in the bins. Participants examined worm cocoons under microscopes, and learned how to take photographs of microscopic images using cell phones. Additionally, they developed testable questions for classroom inquiry, and received lesson plans connected to the Common Core and MSCF standards.
Water Chemistry

Participants brought in water samples and measured water parameters including turbidity, temperature, phosphates, hardness, total dissolved solids, nitrates, carbon dioxide, and pH using probes, test kits, and other scientific equipment in a science laboratory. They explored the effects of hardness on the cleaning properties of soap, the impact of temperature on dissolved oxygen levels in water samples, and investigated the relationships between nitrate and phosphate levels in contaminated water. Each teacher received a portable pH probe and learned how to calibrate, store, and utilize it in their classroom for future experiments.

Microorganisms

Teachers learned about general characteristics of bacteria, algae, fungi, protozoa, and viruses; the importance of microbes regarding plants, wildlife, and human health, their importance as basal members of food chains, and how they can contribute to eutrophication of water bodies and death of fish and animals. They became skilled at measuring biochemical oxygen demand (BOD) and realized that high BOD values correlated with eutrophication. Participants conducted a microbiology experiment that explored the growth of the cosmopolitan green algae, *Scenedesmus*, using assorted nitrogen, phosphate, and potassium sources. They counted and recorded the number of organisms present per field of view using a compound microscope. They learned that *Scenedesmus* varies in morphology based on nutrient availability (Trainor, Cain, & Shubert, 1976; Grover, 1991). For example, *Scenedesmus* commonly occurs in colonies consisting of two, 4 or 8-celled coenobia but in mediums with low phosphorous or salt concentration, the growth forms are unicellular and round to elliptical in shape.

Parasites

Participants examined four genera and associated species of mosquitoes that occur in freshwater environments throughout the Delta. They found out that the blood feeding habits of female mosquitoes cause them to be biological vectors for transmitting diseases such as malaria, West Nile virus, St. Louis encephalitis, and yellow fever that affected the Mississippi Delta region in the past. Malaria afflicted many people in the Mississippi Delta in the early 20th century and was associated with wet rice fields, a common local agricultural crop (Brentlinger, 2006). West Nile virus, St. Louis encephalitis, and yellow fever are endemic in this area, contributed to thousands of deaths (Nuwer, 1999). Teachers learned that drainage of wetlands and spraying with pesticides helped to eliminate mosquitoes (Prothero, 2005). However, increased rainfall, storms, floods, and elevated temperatures associated with global warming, may escalate transmission of malaria throughout the world especially in poverty-stricken areas (Prothero, 2005). Teachers learned how to: collect mosquito larvae for use in the classroom, determine the sex of mosquitoes, and implement microscope-based activities appropriate to the middle school curriculum (Figure 3).
Adopt-A-Stream

During the Adopt-a-Stream session, teachers used field test kits to evaluate ditches and ponds along the DSU golf course. Participants received two kits containing pH and DO tablets for testing numerous water samples in their classrooms. Additionally, teachers learned that low pH values of small streams can severely affect fish mortality and that early life stages, especially eggs and larvae, are extremely sensitive to acidity (Baker et al., 1996). Teachers discovered how water depth and velocity, type of substrate, canopy cover, and woody inputs affected fish and aquatic invertebrate communities during the outdoor sessions (Smiley, Dibble, & Schoenholtz, 2005).

Lower Mississippi River Overview

Large vertebrates existed in the Mississippi Delta area during the late Pleistocene ice age that spanned from 40,000 - 10,000 years before present. Dominated by grasslands and wetlands, this area was home for numerous vertebrates, many of which are extinct today. American lion (*Panthera atrox*), ancient bison (*Bison antiquus*), black bear (*Ursus americanus*), Columbian mammoth (*Mammuthus columbi*), dire wolf (*Canus dirus*), giant beaver (*Castoroides ohioensis*), great short-faced bear (*Arctodus simus*), Jefferson’s ground sloth (*Megalonyx jeffersonii*), were identified by fossil remains collected from local gravel bars. The diets of these animals were very different from their modern day relatives. For example, the giant beaver ate mainly aquatic plants and were like mini hippos; they did not eat trees (Perkins, 2009). During this session, participants learned about geologic time, saw maps of the North American ice sheets and sea-level changes, viewed images of the landscape, learned about the past ecology, and were able to handle life-size, painted, plaster cast, tooth replicas of mastodon, mammoth, giant bison, and...
horse, and claws from giant ground sloths. Additionally, participants acquired knowledge about the formation and processes of the current Lower Mississippi River Drainage basin, including the creation of oxbow lakes, floodplains, levees and stream erosion. They also discovered that the Mississippi River Delta currently consists of a complex series of seven coalescing sub-deltas created over 8,000 years ago. Teachers were impressed with the effects created by low-cost sedimentators that illustrated how sediments settle on a riverbed or lake bottom. Maps that highlighted how the Arkansas/Mississippi state boundary line has shifted in 10 different places since it was established in 1836 (Owen, Pirie, Draper, 2001) since the river was utilized as the delimiter also surprised them.

Aquatic Macroinvertebrate Communities

Many aquatic macroinvertebrates, including larval stoneflies, mayflies, and caddisflies, clams, snails and worms are sensitive to physical and chemical changes in their habitat and are useful as indicator organisms for pollution. Participants sampled ponds and ditches on the DSU golf course and ponds at the Center for Science and Environmental Education (CSEE) for aquatic macroinvertebrates. They used dip nets and D-frame nets to capture specimens, and identified them to families using handouts (index sheets from Adopt-a-stream), field guides, LaMotte leaf pack flash cards, magnifiers, and dissecting microscopes. They compared the water quality of various sites and documented the abundance and richness of taxa. For example, they noted that the ditches on the golf course had higher species diversity than the open pond because of the increased plant cover, which created more shelter and hideouts. Teachers examined aquatic invertebrate life cycles and diagramed food webs from the collected organisms.

Invasive and Native Plant Recognition

We emphasized the importance of plants and focused on the identification of native, ornamental, and invasive woody plant species that occur in the Mississippi Delta region. For example, red maple (Acer rubrum) and bald cypress (Taxodium distichum) are important native trees, whereas crepe myrtle (Lagerstroemia indica) is an exotic tree that has geographical origins in China and Japan. We stressed the significance of the native bottomland hardwood forest as a valuable food resource for local wildlife: Neotropical migrants, waterfowl, and raptors that utilize the Mississippi flyway that passes through Cleveland, Mississippi. This flyway is an important migratory route that extends from southern Ontario to the Gulf of Mexico. In addition, teachers enjoyed the outdoor activities, including a community vegetation quadrat survey, determining the age of trees by using an increment core borer (Figure 4), and identifying trees that occur on the DSU campus with a dichotomous key. They utilized plant identification brochures, field guides, handouts, herbarium sheets, and websites to categorize endangered, native, and invasive plants that exist in Northwestern Mississippi and throughout the southeastern United States.

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Figure 4. A participant extracts tree cores during the Delta Environmental Education workshop institute.

Vertebrates

Teachers used plaster casts of vertebrate tracks to identify mammals that use aquatic food sources in the Mississippi Delta. Mammal tracks commonly occur along wetland banks and are evidence of predation on aquatic animals. Instructors constructed an animal tracking pit, and examined vertebrate tracks along the edges of ponds to illustrate the interconnectedness of aquatic and terrestrial systems. The sites for these activities were the ponds at CSEE and agricultural runoff areas. Field guides, flash cards, and dissecting microscopes helped participants identify vertebrate animals.

USDA Catfish Facility

Farm-raised catfish is a large aquaculture industry in the Mississippi Delta. As part of this unit, the Delta teachers were able to tour the catfish pond facility associated with the USDA-ARS in Stoneville, MS in a daylong field trip. The teachers learned about hybridized catfish, the costs of feeding them, and how they monitor the fish during production. Teachers handled large catfish and witnessed various stages of their life cycles (Figure 5).
Results

Self-reported Learning Gains

Prior to the workshop, participants were asked to rank their level of knowledge with course topics as 1) completely unfamiliar, 2) only slightly familiar, 3) familiar with this topic, 4) know some about this topic, or 5) know a lot about this topic. We grouped responses of completely unfamiliar or only slightly familiar into the Low Initial Knowledge (LK) category. Teachers reported the lowest initial knowledge on the topics native and invasive species, water quality chemistry, the Adopt-A-Stream program, Common Core standards, and microbiology/growing cultures (69%+ LK). They evaluated themselves as more knowledgeable about aquatic invertebrates, parasites, and geology, with about 50% LK, and most comfortable with the topic of using community resources in teaching (only 37% LK). We assigned “I know a lot about this topic” as High Knowledge (HK). Participants did not rank themselves as having high levels of knowledge about any of the topics prior to the workshop. A post-workshop questionnaire given six months after completion revealed a higher level of knowledge than the initial self-assessed knowledge of workshop topics (Figure 6). Every category saw significant gains after the workshop. The course had a significant impact on teachers’ environmental science knowledge, attitudes, and teaching. One teacher reported, “This 10 day workshop has broadened my awareness of the human impact that is harming the food chains/webs that are located in our wetlands, ponds, and the rivers/streams.”
Figure 6: Participant self-evaluation of initial (a) and post-workshop (b) familiarity with topics covered during the Delta Environmental Education workshop institute.

Learning Gains

Teachers responded to the knowledge gained in the workshop in an open-ended response question. All responses indicated learning gains. One middle school teacher stated, “I think the hands-on approach has helped me to teach with more knowledge about the topics covered.” Another added,
This workshop helped me find effective ways to teach things about the environment in Mississippi and how to carry out specific activities. It was also great to be taught from a variety of professors and experts because they explained the material in different ways.

Knowledge of Eutrophication

The 19 teacher responses included the key ideas to varying extents. Nearly all responses (89%) referenced bodies of water, while only 42% referenced sediments or nutrients and only 37% referenced the concept of runoff. Two responses contained no key concepts of eutrophication, while 90% addressed one or more key concepts (Figure 7).

![Bar chart showing post-workshop understanding of eutrophication.](image)

Figure 7: Post-workshop understanding of eutrophication.

Science Teachers’ Self-reported Needs

Upon conclusion of the workshop, we again asked teachers about their needs. Compared to their initial responses, teachers overwhelmingly reported a need for laboratory equipment and consumable lab supplies (82%). Other needs included real-world applications of science to help students connect to content, training with common core standards, and safety training for running laboratory activities (Figure 6).
Teachers, who attended the workshop, had an increased desire to conduct more field-oriented exercises, and to engage students in more hands-on activities. Most teacher responses indicated that they are incorporating the lessons from the course directly into their classrooms. Follow-up contact with participants six months after the conclusion of the workshop confirmed that many teachers did incorporate environmental science activities directly into the classroom curriculum. One posted, “I really want to be able to bring groups of my students to collect bug samples. I also want to get students in the community to diagnose the health levels of the bayou located in the city.” This shows a desire to incorporate the hands-on training from the workshop in the classroom. Another responded,

I will take my students out to different areas and conduct different experiments in the environment to gain a better understanding, take them out to a stream to check for water quality and invertebrates, and have them play different games that give them greater understanding of food webs and food chains.

Follow-up Activities Improving Environmental Science Education

Following the workshop, teachers received balances, field guides, pH monitors, meter sticks, petri dishes, handouts, glassware, and graduated cylinders that would improve their classroom needs. Science teachers from the region attended additional one-day teacher training environmental workshops that further enhanced their professional development in the sciences. For example, five of the original participants took part in a science inquiry workshop in the spring of 2014. Three other participants have taken classes that partially fulfill the Masters of Science of Natural Science program requirements offered by the university.

Science faculty provided additional science education workshops for middle school students throughout the 2013-2014 and 2014-2015 academic years at DSU. More than 20 participants attended each workshop. Workshops incorporated low cost, hands-on activities

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centered on water, air, and soil quality. Furthermore, new hands-on laboratory activities such as tests for soil porosity, soil fertility, measuring nitrogen oxides in air, and looking at the placement of storm drains using Geographic Information System data, have been incorporated into some of DSU’s environmental science classes: Foundations of Environmental Science (BIO 123), Materials and Methods in Environmental Science (BIO 415) and Environmental Geology (BIO 414). Delta State University conducted Earth-day events for the public in April 2015 and continues to promote environmental activities of students and professors through webpages and DSU’s ‘Media Highlights’. Local environmental science issues also are receiving more regional and national attention. Students and professors at DSU have given presentations at the Mississippi Academy of Science Teachers, the Botanical Society of America, and the Mississippi Academy of Science that focus on global warming, bird conservation, aquatic invertebrates at Dahomey National Wildlife refuge, and native and invasive plants that occur on the DSU campus. Delta State University has seen a substantial increase in environmental science majors since the Delta Environmental Education Project (DEEP) workshop (Figure 9) increasing from 20 to over 40 students currently registered in the discipline and the university has been supportive in keeping this program.

Figure 9: Number of environmental science majors who attended Delta State University from 2010-2015.
Conclusion

Teachers gained valuable ideas for activities to implement in their classrooms, along with the resources needed for implementation. They exhibited changed attitudes toward the environment and the value of involving children in contextualized learning activities. Participants gained specific content knowledge that they are now applying in their classrooms, and ideas about creating connections to the MS Science Curriculum Frameworks and the Common Core State Standards.

Session leaders demonstrated a commitment to hands-on contextualized learning. Participants were engaged in hands-on exploration of the environment, not just learning through traditional lectures and labs. Every session involved the incorporation of real world science, with lessons that moved beyond the classroom to the natural world. Teachers continue to apply their knowledge using soil, water, and community resources. For many teachers, the authentic experience of environmental immersion was evident in their program evaluations. Teachers gained meaningful science content knowledge and the corresponding specific science process skills: microscope use, slide preparation, growing algae samples, sexing mosquitoes, identifying native/invasive species, analyzing a tree core, composting, analyzing aquatic invertebrates, and more.

The DEEP course had both short and long-term goals of improving environmental science education in the region. Two major goals were to expand and improve environmental science teaching skills of teachers in the Mississippi Delta area schools and to increase student knowledge of and interest in basic concepts and methods of understanding local environmental issues pertaining to aquatic food webs. Another long-term objective was to increase interest in environmental science as a course of study and career choice. Each of these goals address needs related to educational outcomes of the 2010 Mississippi Science Curriculum Framework that emphasizes four strands that run throughout the science curriculum: Inquiry, Physical Science, Life Science, and Earth & Space Science. The state deems the majority of the Mississippi Delta school districts Critical Teacher Shortage Areas for the sciences. This project helped empower Mississippi Delta teachers to meet state requirements for science education and earn Continuing Education credits for licensure.

Teachers are now able to utilize the wiki-space to communicate with each other, ask questions, post activities that they are incorporating into their classroom. Faculty is committed to helping teachers acquire adequate resources for their classrooms to conduct experiments from the summer institute. A structure is in place to maintain relationships and continue to empower teachers to improve science learning in the classroom.

References


