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Outdoor Investigations to Connect Water to You

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Students are spending less time outdoors than even a generation ago and are missing out on the positive elements associated with nature. Limited access to clean, safe, open spaces discourages many students from taking part in outdoor activities; therefore, efforts to incorporate outdoor learning through formal experiences are more important than ever before. Using the environment as an integrated context for learning, professors collaborated to develop a program that focused on place-based education while seamlessly integrating mathematics and science. By substituting D-nets for iPods and ear buds, students explored issues related to water quality and conservation. Acting as scientists, they analyzed water samples from three ecosystems to determine possible solutions to water quality problems. While the purpose of this article is to highlight a specific program, anecdotal evidence suggests students came to a better understanding of their own sense of place and are better prepared to embrace future environmental challenges.

KEYWORDS: stem, place-based education, water quality, water conservation

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Put down the iPod. Take out the ear buds. Climb into waist-high waders and grab a D-net. Join us on an environmental journey that takes us from an inside classroom to an outdoor learning experience. We're headed outdoors to explore issues related to water quality and water conservation while seamlessly integrating mathematics with the natural sciences. During a one-week program, middle school and high school students become scientists who learn about water quality by collecting and analyzing data to explore the health of the water bodies, determining possible man-made and naturally occurring factors that impact those ecosystems, and proposing solutions to water quality problems.

Place-Based Education

The purpose of this summer academy, *Get Green for Blue: Outdoor Investigations to Connect Water to You*, was to develop and connect each student's personal *sense of place* through outdoor learning opportunities. The authors used the outdoor environment as a venue for exposing students to activities designed to promote place-based connections with environmental issues. Sometimes called *pedagogy of place*, *place-based education* (PBE) uses the local community, such as a schoolyard, neighborhood, town, or community, as one of the primary resources for learning. Gregory Smith (2002) and David Gruenewald (2003) first articulated the concept of PBE in academic literature. They relied on two sources: David Orr's (1992) ecological education and Paul Theobald's (1997) community-oriented rural education (see also Theobald and Curtiss, 2000). Both Orr and Theobald view education as a political and social means of promoting social and ecological well-being in society.

Engaging students in natural environments has been a goal of education for many years. Although PBE can be traced to Dewey's (1915) experiential approach to student learning in the local environment, PBE's emergence stems from a more recent environmental education foundation formed over the last 30 years. Grounded in the resources and values of the local community in which people live, PBE makes learning more meaningful for students by helping them use, understand, and sustain where they live.

By using the local community as an integrated context for learning, PBE utilizes students' innate curiosities about the natural world around them and connects student learning with their lives and communities. Often used interchangeably with *community-based learning*, *service-learning*, *environment as an integrating concept*, *sustainability education*, and *project-based learning*, PBE acts to increase student achievement and improve a community's environmental quality (Powers, 2004). The context of the community determines the curriculum because communities do not share identical problems; therefore the PBE approach is viable in every community (Baker, 2013). Woodhouse and Knapp (2000) describe several distinctive characteristics including that PBE a) emerges from the particular attributes of place, b) is inherently multidisciplinary, c) is inherently experiential, d) is reflective of an educational philosophy that is broader than economics, namely "learning to earn", and e) connects place with self and community. Sobel (2008) defines *place* in PBE as not just the natural environment, but also the local cultural and built environment. Concerned with the importance of place, researchers such as Sobel (2005) warn there is a serious lack of physical and social relationship-building and connection to the local environment.

Importance of Place-Based Education

A national and global movement is underway to remake education and prepare students for the environmental challenges of the future. Young people today are inheriting a host of environmental challenges, including global climate change, loss of biodiversity, resource depletion, and environmental degradation. These problems require citizens who can think ecologically and understand the interconnectedness of human and natural systems. However, Americans have become increasingly disconnected from the outdoors. Students are spending less time outdoors than they did even a generation ago (Clements, 2004; Dannenmaier, 1998; Louv, 2005; McGinnis, 2003; Rivkin, 1995). Oftentimes, limited access to clean, safe, open spaces discourages many Americans from taking part in outdoor activities. This increasing disconnect with nature has been described by Louv (2005) as "nature-deficit disorder," and because of this reduction in outdoor time, people are developing a fear of the natural world (Sobel, 1996). According to *America's Great Outdoors: A Promise to Future Generations Initiative* (2011), students are missing out on the positive elements associated with time spent in nature. Studies show that time spent in nature can foster mental and physical health, reduce stress and anxiety, and promote learning and personal growth.

Researchers at the State Education and Environment Roundtable found that, in over 40 schools nationwide, when the environment is used as an integrating context in locally based curricula, in-school behaviors and student achievement improved (Lieberman & Hoody, 1998a). A program evaluation conducted by researchers at the Harvard Graduate School of Education for the Rural Trust (1999a, 1999b) concluded that students' academic achievement improves, as well as their interest in the community, when schools and communities work together to design curricular goals and strategies. Furthermore, teachers are more satisfied with their professions, and community members are more connected to schools and students.

Evaluations of PBE programs concluded that students who are engaged in real-world learning versus traditional textbook learning are more likely to succeed. The growing body of research on PBE has shown that using the local natural ecology and projects within the community have positive results in both improving academic achievement and engaging youth in their school and community (Sobel, 2005). Research focused the effectiveness of PBE in elementary and secondary school programs concluded the following results, however indirect: a) significantly enhanced student performance on standardized multi-disciplinary achievement tests (Lieberman & Hoody, 1998b), b) significantly improved student achievement motivation (Athman & Monroe, 2004) and critical-thinking skills (Ernst & Monroe, 2004), and c) more collaborative and interdisciplinary practice, and more frequent use of service learning projects, by teachers (Powers, 2004).

The literature suggests that sense of place encompasses the cognitive, affective, and even psychomotor domains if particular kinesthetic activities are associated with or localized in a particular place (Semken & Freeman, 2008). Although place-based educators recognize the importance of content and skills, they argue that the study of place can help increase student engagement and understanding through multidisciplinary, experiential, and intergenerational learning that is not only relevant but potentially contributes to the well-being of community life (Gruenewald, 2003; Haas & Nachtigal, 1998; Smith, 2002; Theobald & Curtiss, 2000).

Because students have limited outdoor experiences, educators must make intentional efforts to incorporate PBE through both formal experiences and programs like summer academies that propose to get students outside. Knapp (1996) suggests that educators need to complement and expand classroom instruction by providing meaningful, contextual experiences in both natural and constructed environments. Increasingly, students are not getting outdoor experiences, and

the social, physical, and emotional benefits of these experiences give credence to the importance of incorporating PBE through formal and informal programs like the one described in this article. Through participation in meaningful outdoor experiences like the summer academy highlighted later in this paper, students' understanding of their own sense of place in their local communities will reinforce the goal of connecting students to the environment where they live and learn. Educators, then, must help students embrace their own sense of place, which may in fact be their own backyard.

The purpose of this paper is to illustrate a single program model used by the authors to bring middle and high school students outdoors. The program aims to provide the students with a better understanding of their own sense of place, and thereby enable and better prepare them to embrace the environmental challenges of the future. The authors provide information on pedagogy and curriculum development as well as anecdotal evidence of program effectiveness.

Summer Academy Outdoor Investigations

Each summer, three faculty members who teach science and mathematics courses at Northeastern State University invite middle and high school students to participate in an environmental journey made possible by a summer academy grant award from the Oklahoma State Regents for Higher Education. During the week long academy, 8th through 10th grade students become connected to the environment and, through knowledge and experience, should become better prepared to embrace the environmental challenges of the future and their own sense of place. *The Get Green for Blue: Outdoor Investigations to Connect Water to You* summer academy program was held at Northeastern State University Broken Arrow campus (NSUBA) and at Rogers County Conservation District Education Reserve. The students examined the water quality of three water bodies at two different areas within the Rogers County Conservation District Education Reserve and at NSUBA, both of which are located in northeastern Oklahoma.

Detailed Description of Activities

A general overview of the outdoor academy experience is described in Table 1. On the first day, the program commenced with a parent and student orientation, which included a campus tour and information about mathematics and science-related programs at the university. Whether engaged in bench experiments or outdoor data collection, students were taught how to conduct all activities in accordance with appropriate safety precautions and guided by scientific principles. By mid-morning, students were outside gathering their first water samples from the pond located at NSUBA. Once back indoors, the students performed pH experiments on a variety of materials, compared water density and displacement, and began their initial water quality experiments. Faculty also introduced concepts related to environmental health of ecosystems.

The next three days were spent at Rogers County Conservation District Education Reserve. The district provided a guest speaker who helped with activities. The students waded knee-deep into water bodies and collected samples from different ponds at the conservation district. They later analyzed the water for changes in alkalinity, transparency, nitrate levels, dissolved oxygen levels, and temperature. Comparisons were made between the water bodies and the health of the ponds. Macroinvertebrates were also collected and analyzed as indicator organisms for the health of the system.

Table 1

Calendar of Daily Activities

Day	Description of Daily Activities
Day 1:	•Orientation with parents and students. •Project WET* activity "A Drop in the Bucket" to calculate the percentage of fresh water available for human use and to explain why water is a limited resource. •Liquids (e.g. coffee, shampoo, juice) will be tested for acidity using pH paper and pH meters to introduce concepts related to environmental health of ecosystem. •Instruction on safety and the use of water data collection materials. •Hike to a pond on NSU grounds to collect samples. •Data will be collected and analyzed in the field (temperature, dissolved oxygen, transparency, pH, nitrate levels). •Project WET* activity "A Grave Mistake" to analyze data to trace the flow of contaminants in ground water. *Project WET (Water Education for Teachers) is an environmental education program
Day 2:	•Rogers County Conservation District Education Reserve – Field Trip to off campus site(s) where groups will collect samples. •The students will examine reasons for changes in the health of two water bodies; explain the difference between pH and alkalinity; examine reasons for changes in the transparency, nitrate levels, dissolved oxygen, and temperature of the water bodies. •Provide students with promotional items for identity purposes.
Day 3:	•Rogers County Conservation District Education Reserve – Field Trip to off campus site(s) where groups will collect samples and analyze data. •Continue Day 2 activities. •Perform service learning project.
Day 4:	•Rogers County Conservation District Education Reserve – Field Trip to off campus site(s) where groups will collect macroinvertebrates as indicators of water quality; •Indoor data analysis. •Synthesis and application of knowledge learned from previous days. •Connections to water use, degradation, and solutions to water quality problems. •Geocaching outdoor measurement activities. •Presentation preparations using PowerPoint in computer lab at NSUBA.
Day 5:	•Students' qualitative evaluations of the Academy. •Morning – Final student preparations for presentations to the mock Environmental Protection Agency (EPA) board (parents). •Afternoon – Technology based student presentations for purposes of establishing claims regarding water quality and water conservation as a summation of learning related to problem solving, science, and technology.

Throughout the experience, students were encouraged to problem solve. Their challenge was to determine the quality of different water bodies and collect data that would enable them to provide a rationale for their claims. Toward the end of the week, students were placed into groups and randomly assigned a different water body to describe and defend. Groups teamed to prepare PowerPoint presentations, which contained their findings based on both qualitative and

quantitative data analysis. During the final afternoon session, groups shared their presentations with parents and friends, which showed evidence of learning and a newfound passion for the outdoors.

Effectiveness of the Project

The purpose of this math and science summer academy was to reconnect students to the outdoors and encourage appreciation for the world in which they live. At the end of the program students were given informal surveys with open-ended questions. Survey comments from students suggested that these purposes were accomplished. Students reported, *"This summer academy has taught me more about working for the environment."* By the end of the week, students left feeling that *"it is our job to take care of our earth" and that it is "important to maintain our water."* Students concluded, *"that water affects everything"* and came to value *"different explanations of how water is sometimes wasted by humans unknowingly."* With a sense of pride, another student wrote, *"I know how to tell if a water pond or source is healthy."* As instructors, we were thrilled to hear students write in survey responses comments like, *"It [outdoor experience] has shown me to a certain degree my love of nature."* Other favorite outdoor favorite experiences are noted in Table 2.

Table 2

Responses to the Question, "*What Did You Like Best About the Academy?"*

Category of Preference	Number of Responses	Examples of Anecdotal Evidence Based Comments
Getting in the Water	16	I liked putting on the waders and getting in the water. Getting out in the water to test the environment.
Collecting Organisms	7	Collecting the critters. Finding creatures. Going in the water and looking for bugs.
Learning Something New	13	A combination of learning and fun activities. Learning about how to test the quality of water. Bonding with new people and discovering new things

Students also became enchanted with the integrated nature of mathematics and science and how these subjects are not limited to the pages of a textbook or the walls of an indoor classroom space. By the end of the week, students discussed *"how enjoyable math and science can be"* and concluded that *"math is hidden in science."* One of our sophomore student participants reported that she knows *"how to find science in everything."* Regarding a newfound affinity for mathematics, another student reported, *"Math has uses outside the classroom."* One of our middle school participants summed it up well by saying, *"Science and math can be fun."* By seeing mathematics and science work together in concert, students came to see the relevance in each subject, which we hope will spark an interest in studying these subjects in greater depths both in high school and college. It was not at all uncommon to read in student survey responses, *"I am*

more interested in it [math and science]" and *"I want to learn more."* In the end, 34 of the 43 students who completed the survey indicated preference for STEM (Science, Technology, Engineering, or Mathematics) careers and were aware of the importance of taking more math and science to support those career paths.

Implications for Practitioners

Specific academy experiences have been described so that practitioners can replicate our program. Other suggestions are provided here for the purpose of developing and connecting each student's personal sense of place through outdoor learning experiences. For those practitioners who have not yet incorporated PBE into the curricula, don't feel the need initially to develop a lengthy project of magnitude. Start small. Take students outdoors and utilize your own school site. For example, observe cloud formations to make weather-related connections. Catalog and classify flora and fauna. Switzer (2014) suggests ways to engage students living in an urban environment by seeking green space elsewhere, such as in a community park or recreation area. Be aware that practitioners do not have to be content-specific experts in order to engage students in PBE. It is important that practitioners provide students the opportunity to develop ownership for their learning by encouraging them to develop questions, conduct research, and implement their own project ideas.

Utilize the resources available to you through technology, your schools, communities, and local and state agencies. Collaborate with community and national partners such as zoos, aquariums, state and national parks, and local and national agencies such as the National Aeronautics and Space Administration or the U. S. Fish and Wildlife Service. Many of these partners are dedicated to providing free resources. Seek out partnerships with faculty and students in ecology classes situated within local community colleges or universities. Other specific suggestions include: a) vocabulary nature walks, b) design and plant a pollinator garden at your school, c) visit your community wastewater treatment plant or bring the plant representative to your classroom, and d) utilize free educational resources made available through Ag in the Classroom (www.agclassroom.org), Global Learning and Observations to Benefit the Environment (www.globe.gov), NASA (www.nasa.gov), Project WET (www. projectwet.org), Project WILD (www.projectwild.org), or Project Learning Tree (www.plt.org).

Conclusion

While our initial goal was to attract middle school and high school students to the benefits of higher education and STEM careers in particular, the academy experience evolved into so much more. As our student participants engaged in outdoor learning experiences, they discovered a new passion for the environment in which they live, work, and play through PBE. School subjects that may have previously seemed stale through mere textbook explorations and an inside-out directional view became real and vivid through hands-on learning opportunities. It is remarkable to see what can happen when students today put down the iPods, take out the ear buds, and climb into waist-high waders. Getting students outdoors is a step in the right direction as part of a national and global movement to remake education and prepare students for the environmental challenges of the future in their own sense of place.

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