

ARTICLE

Special Feature: Broadening perspectives

Community-engaged learning to broaden the impact of applied ecology: A case study

 Heather D. Vance-Chalcraft¹  | Na'Taki Osborne Jelks² 

¹Department of Biology, East Carolina University, Greenville, North Carolina, USA

²Environmental and Health Sciences Program, Spelman College, Atlanta, Georgia, USA

Correspondence

Heather D. Vance-Chalcraft
 Email: vancechalcraft@ecu.edu

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Abstract

Ecological changes are creating disruptions that often disproportionately impact communities of color and economically disadvantaged areas. Scientists who study the consequences experienced by these communities are uniquely suited to bring the public into their work as a way of setting conditions that enable impacted residents to empower themselves to advance environmental and community change. In addition to involving community stakeholders in the process of science, community science can be used to motivate learning and increase engagement of students. Here we highlight a case study of one way a historically Black college involved local communities and students in water quality monitoring efforts to examine the role of the environment in human health. Students in an introductory-level environmental toxicology course collaborated with community members to track pollution and monitor conditions in an urban, impaired stream. Students participated in bi-monthly water quality monitoring alongside community watershed researchers and an annual day-long multisite sampling event with community residents and organizations. Through this engagement, students and community members contributed to the collection of data, learned about the significance of their results, and translated findings into strategies to advance watershed restoration, health, quality of life, and environmental justice goals.

KEYWORDS

case study, community partnership, community science, higher education, Historically Black Colleges and Universities (HBCU), post-secondary, Proctor Creek Watershed, public participation in science, undergraduate, water quality

INTRODUCTION

Global climate change, environmental pollution, and other ecological changes are creating disruptions that disproportionately impact communities of color and economically disadvantaged areas (Freudenberg et al., 2011;

Schaider et al., 2019; Schlosberg & Collins, 2014; Shonkoff et al., 2011). Ecologists and environmental scientists are uniquely suited to bring the public into their work on the consequences experienced by these communities from environmental change. Such collaborations can create conditions through which impacted residents

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can empower themselves to advance environmental and community goals. While public participation in science can take many forms (Bonney et al., 2016; Cooper et al., 2021), we focus on community science.

Many community science projects and other participatory approaches to research are developed by members of the public and focus research on local or regional issues with the goal of affecting policy or local decision-making for public health or conservation (Bonney et al., 2016). These projects can shape policy (Minkler et al., 2008; O'Fallon & Deary, 2002) and increase public understanding of science (Ballard & Belsky, 2010). Community science can broaden the definition of science and can leverage the expertise of underrepresented groups (Birmingham & Calabrese Barton, 2014). Moreover, the relationship between science and the community can be altered by promoting educated action in a community (Birmingham & Calabrese Barton, 2014).

In addition to involving community stakeholders in the process of science, community science can be used to motivate learning and increase engagement of students in higher education. Calls for change in biology education have urged instructors to expose students to interdisciplinary learning and authentic real-world experiences as a means of developing competencies in research and scientific communication (AAAS, 2011). Involving students in community science is one way to do so. Community science incorporates the principles of place-based, active, and community-engaged learning, all of which have broad conceptual and empirical support in educational literature (e.g., Driessen et al., 2020; Fitzgerald et al., 2012; Freeman et al., 2014; Haywood et al., 2016; Johnson et al., 2020; Knapp, 2005; Smith, 2007). Community engagement helps empower students to gain self-awareness and learn strategies to address social injustice (Reddix, 2020) by exposing them to a wide range of perspectives and experiences (Malotky et al., 2020).

Place-based education is rooted in the field of environmental education and, "... it uses the full range of local environments—natural, economic, social, political, and cultural—as the foundation for learning," (public communication, Center for Place-based Learning and Community Engagement). The three primary goals of place-based education include: (1) boosting student engagement, academic achievement, and a sense of efficacy as stewards of one's local environment and community; (2) forging strong ties between local social and environmental organizations as well as their constituencies in schools and the community, thereby helping to improve quality of life and economic vitality; and (3) fostering ecological integrity by helping students make tangible contributions to resolving local environmental issues and conserving local environmental quality

(public communication, Center for Place-based Learning and Community Engagement).

Integrating community science learning experiences into environmentally related courses may help to broaden participation and interest in ecology because these approaches have been shown to be particularly effective at improving interest and academic achievement for underrepresented minorities in science (Estrada et al., 2016; Garibay, 2015; Puritty et al., 2017). Moreover, emphasizing the communal goals of science and exposing students to the interdisciplinary and collaborative nature of science may improve recruitment and retention of underrepresented minorities (Malotky et al., 2020). Diversification is greatly needed as ecology is frequently associated with white culture (Stapleton, 2020) and there is an increasing dialogue about strategies to broaden inclusion in ecology and environmental biology (Bowser & Cid, 2021; Ellison et al., 2021; Miriti, 2021). A diverse workforce with varied perspectives is critical as many environmental challenges cross political and cultural boundaries (Malotky et al., 2020).

Historically Black Colleges and Universities (HBCU), in particular, are well suited for community-based participatory approaches. The history, relationship to community, and commitment of faculty and students at HBCUs mirror the focus in community-engagement approaches on partnership, equity, and social justice (McFarlane-Alvarez & McDonald, 2020; Reddix, 2020; Sydnor et al., 2010). The HBCU faculty, and their institutions, tend to develop strategies that incorporate a community focus into faculty responsibilities and students who attend are often motivated to engage in civic responsibility and connect with their cultural roots (Sydnor et al., 2010). While other institutional types also have characteristics suitable for community-engaged approaches, the core mission of HBCUs highlights that these qualities are often present by design (Sydnor et al., 2010).

Here we highlight a case study of one way a historically Black college involved local communities and students in water quality monitoring efforts to examine the role of the natural environment in human health. This collaboration yielded benefits to both the community and undergraduate students. This case study provides an example for instructors and community leaders interested in creating community science projects to address issues of local concern in their area.

PROCTOR CREEK IN PERIL

Proctor Creek is an urban stream that starts underground in downtown Atlanta, Georgia; daylight above ground near the Atlanta University Center Consortium (AUCC),

the oldest and largest consortium of HBCUs in the world; and flows west for 9 miles until it reaches the Chattahoochee River. The creek is the only major tributary to the Chattahoochee that is solely located in the City of Atlanta (US EPA, 2017), and it has been a source of concern for watershed residents, government agencies, and other stakeholders as far back as the early 1900s when Black Proctor Creek Watershed residents sued and won a case against a furnace company that was illegally dumping trash in the creek (Samuel, 2017). Despite documented pollution challenges, the creek has been a source of pride for West Atlanta communities as a waterway where watershed residents have historically played, fished, and swam (Jelks et al., 2020). In the early to mid 1900s, some local churches were also using the creek as a place for baptisms prior to the building of modern sanctuaries with indoor baptismal pools (LSBC, 1978). In addition to the environmental degradation that plagues the Proctor Creek Watershed, its primarily Black residents experience social and economic disparities (Jelks et al., 2018). In 2013, the Proctor Creek Watershed was identified as a priority location for the Urban Waters Federal Partnership (UWFP), a national initiative led by the United States Environmental Protection Agency (public communication, US EPA) to reconnect urban communities to their waterways through improved coordination among federal agencies and targeted action to engage environmentally burdened and economically distressed populations and other stakeholders in watershed restoration and community revitalization (public communication, US EPA).

As an AUCC member institution, Spelman College is located in the Proctor Creek Watershed, providing an ideal opportunity for classroom-based studies about local ecological resources to be situated in the context of the watershed itself. The watershed's socio-ecological history, its current challenges, ongoing community-led and institutional efforts to improve environmental conditions therein, and proposed solutions to facilitate watershed restoration all became part of place-based and community-engaged activities.

COURSE INVOLVEMENT WITH THE PROCTOR CREEK WATERSHED AND COMMUNITY

Spelman College is a historically Black college for women and a global leader in the education of women of African descent located in Atlanta, Georgia. As a liberal arts institution, it is not uncommon to identify courses across the college's curriculum that use community-engaged approaches as pedagogical tools, even in scientific

disciplines. One such example of the use of community-engaged learning has been demonstrated in an undergraduate, introductory-level environmental toxicology course. Students were taught foundational concepts about the sources, fate, and transport of environmental contaminants and pollution in the environment; the human and ecological health effects of said contaminants and pollution in air, water, and soil; and introduced to human health and ecological risk assessments. In addition to these foundational concepts, courses offered integrated field experiences in which students engaged in monitoring air and water quality, in collaboration with and for the benefit of local environmentally overburdened communities that were disproportionately exposed to environmental hazards and pollution. The course was an elective for students pursuing Bachelor of Science degrees in both environmental science and health sciences as well as the Bachelor of Arts degree in environmental studies.

The water quality field experience partially fulfilled the following course learning objective: (1) Students will be able to generally explain the potential fate and effects of a contaminant in the environment; (2) Students will be able to appreciate and discuss the role that technology and industrial production plays in our society and its capacity to alter the quality of the environment as well as solve problems caused by human impact; and (3) Students will be able to make informed decisions regarding the toxicity of pollutants in the environment, their origins, and mitigation strategies that are protective of the environment and the health of the public. In addition to fulfilling key learning objectives for the course, the engagement in water quality monitoring helped to advance the ongoing efforts of community-based organizations and other stakeholders to collect data and analyze pollution trends and improvement in Proctor Creek water quality over time.

In the introductory environmental toxicology course, place-based learning was approached, in part, through engagement activities that both facilitated and prepared students for interactions with community members. These activities included reading peer-reviewed literature and articles from local periodicals about local environmental conditions in the focal watershed, an introductory lecture and classroom discussion about local environmental challenges in proximity to the campus, participation in an instructor-led windshield tour of the watershed community, student attendance at a community meeting alongside Proctor Creek Watershed residents, and taking Proctor Creek samples and monitoring community environmental conditions near locations where water samples were collected, in collaboration with community members. Integration of these activities in the course

curriculum mapped onto the goals of place-based education as well as the student learning objectives (Table 1). In each iteration of the course, data collected in previous semesters were explored as a part of the introductory lecture delivered by the instructor and the background literature and materials that students read in preparation for their field experiences. New data collected in each successive semester also contributed to ongoing environmental monitoring efforts in the community and were added to the same central data repository as were the previously collected data.

COMMUNITY-ENGAGED ACTIVITIES

During the course of the semester, students collected water samples twice monthly at select locations along Proctor Creek to identify specific pollutants and sources of pollution and to hypothesize about potential water quality impairment based on excessive levels of contaminants of concern. These sampling efforts were conducted both independently and in collaboration with Proctor Creek Watershed residents who served as community watershed researchers through their engagement with the Neighborhood Water Watch program, an initiative of

the Chattahoochee Riverkeeper (CRK), a locally based, statewide advocacy organization that is dedicated to protecting and restoring the Chattahoochee River Basin. Until the recent acquisition of equipment and supplies to process and analyze samples on-site at the college, these water samples were primarily processed by water quality professionals as part of the Neighborhood Water Watch. The samples were assessed for levels of *Escherichia coli* bacteria, a possible indicator of sewage pollution, the presence of optical brighteners, and conductivity. Conditions around the stream sample locations were also qualitatively noted by student data collectors: the presence and type of algae (blue/green, brownish) as well as the state of the algae growth (present in mats, lightly coating water, present in spots, filamentous, heavily coating water, or semistagnant), water color, appearance of the water surface (clear, appearance of an oily sheen that does or does not break apart, white tint), the presence and magnitude of foam (greater than 3 inches or less than 3 inches), water odor, the presence of trash, and presence or evidence of wildlife. To examine trends over time, students explored Proctor Creek water quality data collected through the Neighborhood Water Watch program, in which consistent sampling methods were used and conducted at similar times of day on the same day of the week. When attempting to interpret their own

TABLE 1 The introduction to environmental toxicology community-engaged learning activities.

Engagement activity	Correlation to place-based education goals	Linkage to student learning objectives
Community windshield tour	Boosts student engagement and sense of efficacy for environmental stewardship in one's local environment and community	Students will be able to appreciate and discuss the role that technology and industrial production plays in our society and its capacity to alter the quality of the environment as well as solve problems caused by human impact; Students will be able to generally explain the potential fate and effects of a contaminant in the environment
Attendance at community meetings	Forges strong ties between local social and environmental organizations as well as their constituencies in schools and the community; boosts student engagement	Students will be able to make informed decisions regarding the toxicity of pollutants in the environment, their origins, and mitigation strategies that are protective of the environment and the health of the public
Water quality monitoring; environmental monitoring in collaboration with watershed residents	Boosts student engagement and sense of efficacy for environmental stewardship in one's local environment and community; fosters ecological integrity by helping students make tangible contributions to resolving local environmental issues and conserving local environmental quality; forges strong ties between local social and environmental organizations as well as their constituencies in schools and the community	Students will be able to make informed decisions regarding the toxicity of pollutants in the environment, their origins, and mitigation strategies that are protective of the environment and the health of the public; students will be able to generally explain the potential fate and effects of a contaminant in the environment

findings, students triangulated the quantitative (water quality monitoring) data and qualitative data about neighborhood and stream conditions to develop their hypotheses and to develop recommendations for mitigation strategies in consultation with community watershed researchers who offered their lived experience and local community knowledge to inform said recommendations.

In addition to the bi-monthly water quality monitoring alongside community watershed researchers over the semester-long course, students also participated in an annual day-long multisite sampling event, the Westside River Rendezvous, with community residents, volunteers, and staff from community-based organizations, such as the West Atlanta Watershed Alliance, the Proctor Creek Stewardship Council, and Chattahoochee Riverkeeper. The aforementioned water quality parameters and site conditions were also the focus of the River Rendezvous event. While the River Rendezvous was focused on gaining a 1-day snapshot of water quality in three contiguous watersheds in the western quadrant of the City of Atlanta, the Proctor, Utoy, and Sandy Creek Watersheds, students in the environmental toxicology course were specifically paired with community residents and dispatched to predetermined sampling locations along Proctor Creek and its tributaries. At each site, the pairs collected grab samples streamside by hand or from bridges with the aid of a bridge sampling device. On the day of the River Rendezvous sampling event, a select group of approximately four students helped staff from the on-site laboratory and were trained by Chattahoochee Riverkeeper staff to process samples being delivered from stream segments across the three target watersheds.

After participation in the aforementioned field activities, students were given reflective prompts to which they responded about what they had learned, the importance of working collaboratively with community members to help address a challenge of concern to the community, how the field experiences helped to inform their understanding of the importance of water quality monitoring, what new skills they may have learned, if any, to help them address environmental concerns in the local community, and their thoughts about the relevance of the field activities to the study of environmental toxicology.

HOW THIS APPROACH EMPOWERS COMMUNITIES AND ADDRESSES RACIAL EQUITY

This case study exemplifies many of the benefits of community-engaged learning with positive outcomes for students, local residents, and the field of ecology. This teaching approach allowed students to learn disciplinary

knowledge, along with other skills like communication, collaboration, leadership, and cultural competency. Incorporating time for students to reflect on their experiences helped enhance self-awareness, sense of community, and civic engagement (Ash et al., 2005). The real-world skills students developed can be listed on job application materials, making them more desirable to employers (McFarlane-Alvarez & McDonald, 2020). Student interactions with local residents highlighted that the data they collected were immediately relevant beyond the classroom, which is important as student motivation and persistence in STEM has been shown to be enhanced when students view science as having the potential to benefit their community (Malotky et al., 2020; Puritty et al., 2017). The inclusion of introductory-level students in this community-engaged learning may be particularly powerful as this is a stage in which greater numbers of students leave STEM fields, and disproportionately so students from underrepresented groups (Graham et al., 2013). Experiences such as this case study that encouraged learning and the development of professional identification spur students to feel like a scientist, in contrast to many introductory experiences that diminish student confidence and discourage them from pursuing science (Graham et al., 2013).

The field of ecology may benefit in multiple ways from community science. By increasing student persistence in STEM, examples such as the case study described here may provide an additional tool for practitioners grappling with how to diversify the field and broaden participation in ecology. In addition, this type of approach increases the rate of longitudinal data collection through a greater number of people collecting data. Finally, partnering students with local residents creates diverse teams working to address an environmental concern. More diverse teams have been shown to be more innovative and produce more robust recommendations that are more likely to be implemented (National Research Council, 2015).

RECOMMENDATIONS AND CHALLENGES FOR IMPLEMENTING THIS APPROACH

Community-engaged learning approaches can both benefit communities as well as enhance the educational experience for student participants. Alongside benefits, there can be challenges getting started if no prior relationships exist between academics/researchers and the communities in which there is an interest in collaborating. Furthermore, the focus of the research should be of mutual interest to the community, as well as the academic partners with an emphasis on its utility to the community.

For optimal results, it is important that scientists invest in building relationships with community partners in advance of trying to launch a joint research effort. During the relationship cultivation phase, scientists should explore, with communities, common interests in the context of scientific research of importance to community members and organizations. Beginning with a community-developed research question or data collection efforts of importance to the community will ensure that their specific needs and interests are addressed. Preparing students to interact with community residents and to understand community conditions and context through classroom activities, reading assignments, and meeting community members through various activities (community meetings, service projects, or other community events) will also aid in advancing relationships and trust as plans are collaboratively developed around the community-engaged learning opportunity and efforts to advance place-based environmental change.

CONCLUSIONS

Scientists studying the consequences from environmental change have a unique opportunity to bring the public into their work, with the benefit of involving community stakeholders in the process of science. Community science also can be used to motivate learning and increase engagement of students in higher education through place-based, active, and community-engaged learning, strategies that have broad conceptual and empirical support in educational literature. Working in collaboration with community-based organizations, Atlanta-based colleges and universities, including local HBCUs, created opportunities for joint research and learning between students and Proctor Creek Watershed residents. Through this engagement, students and community members contributed to the collection of water quality data in an impaired stream, learned about the significance of their results, and translated findings into strategies to advance watershed restoration, health, quality of life, and environmental justice goals. Community science approaches, like this one, can benefit local communities, students, and the academic institution's engagement with the surrounding city while collecting data that are ecologically valuable to multiple stakeholders. This case study provides an example for instructors and community leaders interested in creating community science projects to address issues of local concern in their area.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

No data were collected for this study.

ORCID

Heather D. Vance-Chalcraft  <https://orcid.org/0000-0002-7230-1342>

Na'Taki Osborne Jelks  <https://orcid.org/0000-0003-3737-4439>

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