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Engaged Environmental Science for Underserved Youth

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Abstract

The National Institute for Environmental Health Sciences has called for targeted efforts to engage underserved youth in environmental education programs that support environmental literacy and contribute to the development of a diverse workforce pipeline for environmental science-related occupations. Evidence suggests that career knowledge among low income and minority youth is more likely to be incompatible with post-secondary educational opportunities than other racial and ethnic groups. One approach to attenuating discordant college and career expectations among underserved youth is building networks for information sharing between secondary and post-secondary students. The purpose of this commentary is to describe the development and implementation of a high school curriculum on environmental science and environmental justice by Texas A&M University in collaboration with community engagement partners, students, and teachers at Furr High School, an innovative XQ Super School in Houston, Texas.

Keywords

Engaged scholarship; environmental health literacy; environmental science education; curriculum

1. Introduction

In the U.S., the National Institutes of Environmental Health Sciences' (NIEHS) most recent strategic plan called for concerted efforts to engage underserved groups in environmental health science through targeted training and education (NIEHS 2018). At the state level, the State of Texas adopted the Texas Natural Resource/Environmental Literacy Plan in 2013 to

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create a framework for fostering environmental literacy and lifelong learning around natural resource stewardship (Texas Children in Nature and Texas Association for Environmental Education 2013). However, in general, these types of plans lack both incentives for implementation (e.g. funding) and enforcement mechanisms (e.g. mandates), leading to low rates of implementation, particularly in time- and resource-limited public schools located in environmental justice neighborhoods. Environmental justice communities are typically comprised of low-income, minority residents at disproportional risk of exposure to pollution and other environmental stressors at home, school, and work (Bullard and Wright 1993). This limits these programs' effectiveness at building an environmental science occupational pipeline among low income and minority youth who are the most likely to face environmental justice issues in their neighborhoods, schools, and homes (Environmental Protection Agency 2017; National Environmental Justice Advisory Council 2018). A more effective model builds in-depth knowledge among youth about environmental issues as well as giving students additional skills in using action strategies to accomplish desired changes (Hungerford and Volk 1990).

University engagement and partnership programs are one setting in which these types of knowledge and skills can be built. However, it is essential that these programs not only produce research findings that can offer solutions to communities, but also that they translate research into action through engagement and create high impact learning experiences for students (Gelmon, Jordan, and Seifer 2013; Berke et al. 2018). While universities are increasingly expected to carry out community-engaged research and engage in translational and educational activities, impactful programs must invest minority youth with a sense of agency (Rodriguez 2008), support them as producers and not only consumers of knowledge (Smith 2002), ensure their active participation in the development of solutions to local environmental problems (Coalition of Essential Schools 2006), and connect local and global issues (Furman and Gruenewald 2004). In addition to these challenges, evidence suggests that discordant postsecondary educational aspirations and desired occupations are more common among socioeconomically disadvantaged adolescents (Perry et al. 2016) and youth age 14 to 18 (Schneider, Kim, and Klager 2017). In other words, students with less access to social and economic resources are more likely to misunderstand the amount and type of post-secondary education required to achieve their desired career path. Discordance in educational and occupational objectives present an additional barrier to achievement in college among youth. However, college-linking networks and peer programs that connect high school students could be an effective solution to this discordance problem (Perna 2000; Hill 2009).

2. The partnership

To build knowledge in environmental health science and environmental justice and facilitate collegiate network-building among underserved, minority youth, Texas A&M University, community engagement partners, and faculty at Furr High School co-developed a six-week curriculum in Spring 2018. Graduate students were recruited to serve as lesson leaders on the basis of interest, subject matter knowledge, and pertinent experience and provided ongoing guidance throughout the lesson development process by Furr High School teachers and staff, along with Texas A&M faculty. The student body of Furr High School is

composed predominantly of minority groups, with 80.0% and 17.1% of students enrolled in the 2015–2016 school year being Hispanic and African American, respectively (Texas Education Agency 2017). During this period, 94.1% of students were economically disadvantaged, which exceeded levels reported for the school district (77.1%) and state (59.0%) (Texas Education Agency 2017). In spite of potential challenges to student success, in 2016 Furr High School's 4-year graduation rate (95.9%) exceeded the state by 6.8% and the district by 15.4% (Texas Education Agency 2017). Partially in recognition of Furr High School's success, in 2016, the school received a \$10 million grant from the XQ Institute's Super School Project, a network of innovative and creative high schools funded to reimagine public high school education in the U.S. to prepare students for college and careers (XQ Institute 2016). The XQ funding supports a reimagined high school where students work closely with teachers to identify topics and design projects that interest them and will help them achieve their personal goals (Rolph 2017). The Institute for Sustainable Communities (IFSC) at Texas A&M University is a group of interdisciplinary researchers, engagement staff, and graduate students from the Departments of Landscape Architecture and Urban Planning, Civil Engineering, Geography, and Epidemiology that was established in 2014 and funded by the Office of Provost and Executive Vice President as part of the University's approach to the Environmental Grand Challenge. The goal of IFSC is to develop better approaches to understanding and addressing the challenges of environmental hazards and supporting the development of sustainable and resilient communities. IFSC researchers and graduate students initially engaged with Furr High School teachers and students by offering training to students in citizen science as part of the School's Genius Time, which provides an allocated class period for students to pursue extracurricular interests and special topics. As part of these activities, ongoing participatory research and place-based education projects have been developed and completed jointly by IFSC faculty, staff, and graduate students in partnership with Furr High School faculty and students based on their interests in improving community resilience to disasters, including assessments of flood resilience in the community (Meyer et al. 2018), resident's health and health perceptions (Sansom et al. 2016, 2017), potential hazardous environmental exposures (Horney et al. 2018), and storm water infrastructure in the East Houston neighborhood of Manchester (Newman et al. 2016).

Building upon this established partnership, Furr High School faculty invited the IFSC to develop and implement a six-week environmental science curriculum aligned with the educational interests and career aspirations of students and targeted to existing needs for extracurricular learning. Consistent with the Committee on Successful Out-of-School STEM's criteria for productive programs (National Research Council 2015), lessons and activities were required to be engaging and responsive while fostering connectivity between concepts and applications. Graduate students were recruited to serve as lesson leaders from the Texas A&M School of Public Health, the Texas Sea Grant College Program, the Superfund Research Center, and the Regulatory Science in Environmental Health and Toxicology Program in the College of Veterinary Medicine on the basis of interest, subject matter knowledge, and pertinent experience. Participation by graduate students was contingent upon the completion of a thorough screening involving the following measures: 1) Registration the Houston Independent School District through the Volunteers in Public Schools (VIPS) program; 2) Application submittal to the Raptor Volunteer Management

System, which conducts background checks and verification of eligibility; and 3) Review and approval by the Furr High School VIPS Coordinator.

Once verified and approved, each leader developed a lesson plan proposal involving engaging, interactive components, clear connections to real-world applications and careers, and dedicated time for student reflection. To ensure plan content and activities were accessible, appropriate, engaging, and of the highest quality, Furr High School teachers and staff, along with Texas A&M faculty, provided ongoing guidance throughout the lesson development process, critically reviewed draft proposals, and granted final approval prior to implementation. Lesson leaders were encouraged to include novel hands-on learning opportunities and provided funds to procure supplies and materials for approved activities.

Financial support of this program was also collaborative. Funding provided by the Texas A&M Superfund Research Center was used to cover operational and logistical expenses pertaining to the Toxic Tour provided by T.E.J.A.S., to acquire resources and supplies needed for lesson implementation, and to reimburse the cost of travel for graduate student leaders from Texas A&M University in College Station, Texas to Furr High School in Houston, Texas. Furr High School allocated funds for transportation of students to Texas A&M University, while the IFSC purchased meals during the campus tour and the Provost's Office of Public Partnership and Outreach donated drawstring backpacks, lanyards, and other branded items that were provided to tour participants.

To address the needs and interests of Furr High School students and faculty, a six-week environmental science curriculum was developed and implemented in Spring 2018 by faculty and graduate students from the IFSC and the Texas A&M University Superfund Research Program's Community Engagement and Research Translation Cores. The program was implemented during 'Genius Time' at Furr High School, which provides an allocated class period for students to pursue extracurricular interests, including physical fitness (e.g. Zumba, weightlifting), skill-building (e.g. plumbing, knitting), and special topics identified by the students such as environmental justice (XQ Institute 2016). Between 30 and 40 students participated in each session of the engaged environmental science program, which they identified as an interest following the severe impacts of Hurricane Harvey on the City of Houston in general and in their communities specifically. At the conclusion of the program, short videos summarizing each topic in English and Spanish were recorded and posted to Facebook. The six-week program included the following modules (Figure 1).

2.1. Environmental justice and toxic tour

Environmental exposure to hazardous industrial releases is a particular concern in the City of Houston, Texas, where residential development differs from other major cities in the U.S. because it is not subject to zoning (Walsh 2018). The resulting distribution of minority and low-income populations has resulted in increased exposure risks to environmental hazards for socially vulnerable groups. Community engagement in environmental protection has increased over the past several decades in Houston in response to the growing recognition of the differential exposures, unequal enforcement, and discriminatory land use practices present in environmental justice communities (Bullard and Johnson 2000). The first lesson involved a chartered 'Toxic Tour' led by the Texas Environmental Justice Advocacy Services

(T.E.J.A.S.), a local environmental advocacy group that regularly provides tours to educate community members about environmental advocacy action strategies, as well as to increase the knowledge and awareness of environmental justice communities and concerns. The tour included visits to key sites concerning current and previous environmental justice issues in Houston and illustrated inequities in hazardous environmental exposures among disadvantaged populations. The tour responded specifically to student interest in gaining skills in identifying ways communities are differentially impacted by pollution, as well as providing students with tools for advocacy.

2.2. Environmental health research

In the neighborhoods located along the Houston Ship Channel, residents have excess risk of exposure to both chronic pollution and emergency spills and other manmade disaster events (Chakraborty et al. 2014; Union of Concerned Scientists 2016; City of Houston Planning and Development Department 2017). This excess risk has been linked to poor health outcomes, including cancer clusters and increased prevalence of respiratory diseases (Texas Department of State Health Services 2015; Whitworth, Symanski, and Coker 2008; Sexton et al. 2007; Linder, Marko, and Sexton 2008). The second lesson highlighted the interdependencies of environmental and human health, with a special focus on anthropogenic factors contributing to greenhouse gas production and climate change. The role of the carbon cycle in regulating atmospheric gases and global temperature was explained, and an experiment was used to demonstrate the positive feedback cycle of warming oceanic temperature resulting in reduced carbon dioxide (CO₂) solubility in water and higher atmospheric levels of CO₂. Resources to access community-level air quality data and other local environmental health research findings were provided, including a searchable database for local environmental health data hosted by the Texas A&M Superfund Research Center (www.stayconscious.org).

2.3. Disaster tabletop exercise

The Texas Commission on Environmental Quality (TCEQ) has been criticized for a lack of oversight on industrial emissions of air (Ozmy and Jarrell 2011) and water pollutants (Berg, Kim, and Rumpel 2018), as well as poor prosecutorial enforcement against violators (Ozmy and Jarrell 2017). Both Federal- and state-level environmental monitoring in Texas has drawn increased scrutiny in the aftermath of Hurricane Harvey, a Category 4 storm that made landfall on the Texas Gulf Coast on the evening of August 25, 2017 and resulted in up to 33 trillion gallons of rainfall in the week that followed (Texas Commission on Environmental Quality 2018). According to TCEQ's Hurricane Harvey After Action Report (Texas Commission on Environmental Quality 2018), more than 270,000 homes and 61 community water systems were incapacitated or destroyed by the storm. The tremendous impacts of the storm included the proliferation of physical, biological, and chemical hazards in the environment from submerged and debilitated wastewater treatment plants, at least 1,155 displaced contaminated drums, and hundreds of hazardous waste spills or discharges (Texas Commission on Environmental Quality 2018). The impacts of Hurricane Harvey highlighted for many, including our established community engagement partners and students and teachers at Furr High School, the importance of access to information that could improve their understanding of the potential health and environmental impacts of

natural disasters (Hatfield 2018). High school students participated in a hurricane scenario tabletop exercise facilitated by graduate students focusing on the vulnerability of Houston residents to natural disasters and demonstrating the importance of pre-disaster preparedness for optimal response and recovery in the third lesson. In addition to the tabletop, Furr students reviewed local and community-level disaster response and recovery plans and discussed community resilience and the secondary impacts of disasters on environmental health due to contamination. Texas A&M staff provided disaster preparedness resources and planning guides in English and Spanish to assist in the development of household disaster preparedness plans.

2.4. Household exposures and action

Racial and ethnic minorities are disproportionately challenged by financial stressors and are less likely to live in affluent areas or owner-occupied homes, which often limits access to high-quality public schools and other neighborhood amenities (Grunsky, Mattingly, and Varner 2017). Housing located near industrial areas is typically more affordable; however, living in close proximity to emitters of environmental hazards can induce additional burdens on health, thereby reducing quality of life (Bullard and Johnson 2000; Chakraborty et al. 2014; Yacovitch et al. 2015). The fourth lesson introduced household-level exposures to chemical hazards, including contaminants commonly present in yard soil and endocrine-disrupting chemicals found in certain consumer products. Household-level actions to reduce potential chemical exposures and to promote environmental health were also described. Students played a jeopardy-style game to assess knowledge of recycling, encourage sharing of personal perspectives, and facilitate discussion about opportunities to integrate practices to protect human and environmental health in daily life.

2.5. Participatory action and activities

Progress in mitigating the risks from unequal exposure to environmental hazards necessitates an approach that involves academia, community-serving organizations, and governments, among others (National Institute of Environmental Health Sciences 2018). One way to empower underserved youth in environmental justice neighborhoods is building ownership and empowerment around relevant issues in environmental health science and environmental justice (Hungerford and Volk 1990). Furr students learned about the role of community-serving and non-profit organizations in promoting community sustainability through grassroots advocacy and community-level action in lesson five. Students viewed interviews with key figures in collective, grassroots initiatives to see examples of successful community-level action. Disparate burdens faced by minority groups were discussed – for example, in Houston minority and low-income residents have excess risk of exposure to both chronic pollution and emergency spills (Chakraborty et al. 2014; Union of Concerned Scientists 2016) and higher prevalence of some cancers and respiratory conditions (Sexton et al. 2007; Linder, Marko, and Sexton 2008) – along with opportunities to become involved in local environmental justice activities.

2.6. University Campus Tour

To deepen the interpersonal connection between Furr High School students and graduate students at Texas A&M, the program culminated in a campus tour at Texas A&M University

that highlighted college and career pathways in environmental science and community sustainability. Furr students selected the Departments of Ecosystem Science and Management, Soil and Crop Sciences, and Poultry Science as areas that offered degree programs that matched their potential career goals. Faculty and graduate students accompanied high school students and shared advice, setbacks, and experiences, including funding opportunities for undergraduate education and other resources for collegiate transition and success. Students received materials from the Department of Wildlife and Fishery Sciences, the Department of Animal Science, the College of Architecture, and the School of Public Health, as well as the Office of Financial Aid and Residential Services.

3. Discussion

The program described above was developed to provide educational opportunities and hands-on learning experiences in environmental health science and environmental justice and to encourage the development of healthy, sustainable communities by empowering underserved, minority youth to apply to and enroll in college-level programs in environmental science. Building upon established community partnerships, the six-week engaged environmental science program was tailored to the needs and interests of Furr High School students and teachers. The program also benefited from the involvement of T.E.J.A.S., a local environmental advocacy group, as well the opportunity for students to visit Texas A&M University and further develop connections to support college and career aspirations. The curriculum will be presented to high school principals in Texas as part of the STEM for Innovation Conference, an interactive conference for K-12 STEM educators, administrators, and counselors from across Texas, and there are plans to deliver a modified version to students at high schools in environmental justice neighborhoods in both Houston and Dallas.

Community-engaged scholarship is inherently challenging. Initial lesson proposals highlighted a tendency among graduate student leaders to defer to a the traditional format of teaching, whereby a formal lecture would be used to convey key concepts and a worksheet would provide a means of evaluating concept proficiency. The iterative process of lesson development entailed early and frequent feedback from instructors at Furr High School and Texas A&M University and enabled timely redirection that fostered greater student engagement through experiential learning. Efforts to ensure that content was tailored to the unique backgrounds, interests, and cultures of Furr students resulted in a locally responsive program; however, these efforts simultaneously detracted from the program's generalizability and transferability. For example, Spanish-speaking Hispanic graduate students in STEM fields at Texas A&M University designed and implemented the program. Subsequently, faculty and staff presented the program to principals from other Texas high schools as part of the STEM for Innovation conference at Texas A&M (<https://stem4innovation.tamu.edu/>) and a second offering of an adapted program is planned in Jones High School, a majority African-American high school in Houston.

Evaluation of community-engaged programming in this setting has been difficult in our experience because the traditional metrics of success in academia and the means in which they are measured may not be feasible or appropriate. In addition, due to the complexity of

obtaining Institutional Review Board (IRB) approvals for the collection of data from participants under age 18 – the IRB required written parental consent for student participation in evaluation activities for a similar program carried out by this engagement team at Furr High School, which was difficult to obtain due to general distrust, lack of translation activities from prior research, limited English proficiency among parents, and accessibility since many families work one or more low-wage jobs (Meyer et al. 2018) – there was no formal evaluation process. These challenges were far surpassed by the benefits of this program, which included opportunities to engage minority youth in environmental health research topics, the provision of information to support individual- and household-level actions such as preparing a household disaster preparedness plan, the establishment of college-linking networks for Furr students, and opportunities for graduate students to acquire hands-on experience in lesson development and teaching. For example, a community partner at T.E.J.A.S. pointed to the ‘empowering force of environmental education in marginalized communities’. One graduate student instructor described the benefit of the program’s engagement, crediting it with making them ‘a more successful and confident facilitator, mediator, listener, and problem-solver’. One of the graduate students received the Margaret Rudder Community Service Award, one of six awarded annually to a student at Texas A&M who made a significant community impact, in part for his work with the Spanish Facebook videos and the development of a website that the students could use to map potential contamination sites in their neighborhoods. The frequent engagement and interaction between IFSC members and Furr High School teachers provided by this program strengthened the partnership from which it was built.

The importance and impact of this partnership extends beyond this sole program, however. On March 17, 2019, a fire ignited at the Intercontinental Terminals Continental petrochemical facility, which is located along the Houston Ship Channel and less than 10 miles away from the Furr High School campus (Texas Commission on Environmental Quality 2019). Furr High School teachers organized a forum on March 21, 2019 involving affiliates of both IFSC and T.E.J.A.S. to engage and educate their student body, staff, and community members about fire-related health and safety concerns (Furr High School 2019). On the same date, students and staff of the Texas A&M IFSC and Superfund Research Center conducted rapid air quality testing and collected soil samples from the vegetable gardens of Furr High School and two nearby elementary schools to determine the extent and risks associated with chemical exposures resulting from the fire. The researchers returned on March 22, 2019 following a secondary fire at the same facility and provided immediate warning of elevated benzene concentrations (0.001 ppm) in outdoor air of the Furr High School campus. By working collaboratively, Furr High School teachers, local environmental advocates, and academic faculty, staff, and graduate students are working to protect and develop the next generation of environmental scientists, natural resource stewards, and civic leaders.

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Figure 1.
Furr High School “genius time” lesson topics and timeline.