Effects of the engagement in authentic water and sanitation research on Ghanaian high school students and teachers

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Abstract

This symposium reports on a study done in Ghana to understand how participation in authentic water and sanitation research affects students' learning of science practices, their attitudes toward science, their interest in science-related careers, and their identities as scientists. It also sought effective ways to scaffold science teachers' engagement of their students in authentic science activities. It was found students increased their knowledge of science and their ability to engage in science practices; they increased their interest in STEM-related careers; and they took on identities as scientists. Teachers gained new content and pedagogical methods to incorporate in their teaching.

Purpose

In this study we sought to investigate how participation in an authentic science project affects students' learning of the practices of science, their attitudes toward science, their interest in science-related careers, and their identities as scientists. The authentic science project in this study involved high school students and teachers, and university researchers investigating the use of anaerobic biodigesters to convert food and livestock waste to useable energy (methane) and fertilizer. Our research questions were:

1. How did the students' participation affect their learning of the practices of science?
2. How did their participation affect their attitude toward science, including their interest in science-related careers?
3. How did their participation affect their identities as scientists?
4. What are effective ways to scaffold science teachers' engagement of their students in authentic science activities?

Rationale and background

Internationally, science literacy includes the competencies to explain phenomena scientifically; interpret data and evidence scientifically; and evaluate and design scientific inquiry (OECD, 2018). Similarly, in the US A Framework for K-12 Science Education (National Research Council, 2012) calls for students to become scientifically literate and to engage in the practices of science and engineering. One way for them to learn to do so is to engage in authentic science activities, i.e., in ways that are similar to those of scientists (Lee & Songer, 2003). Although previous studies support the idea that these types of experiences are highly beneficial (e.g., Chapman & Feldman, 2017), students rarely have them in science classes. In Ghana, where this study took place, studies have found the same lack of opportunity. For example, there is evidence that high school students in Ghana rarely reported engaging in the practices of science (Azure, 2015).

In the US, lower funded schools do not have access to resources such as textbooks and laboratory equipment that is available to students in wealthier communities (Barton & Yang,

2000; Basu & Barton, 2007; Oakes, 2000; Seiler, 2001; Zacharia & Barton, 2004). This exacerbates the achievement gaps between students in the lower resourced and wealthier communities, and has led to the marginalization in science of students who live in poverty, as well as English Language Learners (ELLs), and students of color. In Ghana there are significant differences in the educational opportunities among urban, rural, and periurban schools. There are also differences in family resources due to varying income levels and education of the students' parents (Ansong et al., 2015; Balwanz & Darvas, 2013). Because the language of instruction is English, another factor may be the amount of use of English in the home. In addition, gender inequalities have been found in schools (Senadza, 2012).

Therefore, in this study we sought to expand our study of the effects of students' participation in authentic science activities in the US to Ghana and seek to understand how participation of Ghanaian secondary students in an authentic science research project along with university researchers affects their learning of and attitudes toward science.

Data source (population, sample, setting)

The authentic science experience was part of a collaborative research project between a university in Ghana and one in the US, along with the participation of a local Ghanaian high school. The study received funding from the National Science Foundation (NSF), and was IRB approved. The study participants were Ghanaian high school students who volunteered to be in an afterschool science club (33 students) and two of their teachers. All the students and their guardians gave assent and consent to participate in the study. The two teachers also gave their consent. The science club met four afternoons per week for approximately 1 ½ hours for each session. US and Ghanaian graduate students, and the Ghanaian teachers collaborated to run the club. The students were divided into six groups, each led by one of the graduate students.

Methods

This was a mixed-methods study (Onwuegbuzie & Johnson, 2004) in which we used quantitative and qualitative data to answer our research questions. Our data consisted of audio recorded interviews of the teachers and selected students; a student pretest and posttest; observations of the teachers and students engaged in the project; and students' work that they produced as part of their participation in the project. Data were analyzed using the coding of qualitative data (Miles, Huberman, & Saldaña, 2014), assisted by the use of NVivo. Pre-conceived categories for coding were derived from the literature, while emergent categories were derived inductively from the data, following the methods of the development of grounded theory (Corbin & Strauss, 2015). Pre- and post-test results were analyzed using descriptive and inferential statistics. The students and teachers were observed during every meeting of the afterschool club.

Results and conclusions

Research question 1: Our data clearly show that the students' participation in the biodigester project increased their abilities to engage in the practices of science. The pre-test/post-test comparison showed a significant increase in the students' knowledge about the practices. We observed the students engaging in the practices during every club session, and found evidence of this in their poster presentations. In interviews they described the ways in which they made measurements and observations, and analyzed data. Importantly, most of the students reported that they never had the opportunity to experience authentic science activities previously.

Research question 2: We found that students were able to make connections between sciences and other discipline. Some students' interests in science were reaffirmed in doing the biodigester project because they "enjoyed" engaging in the practices of science. Others gained new interest in pursuing a STEM-related career.

Research question 3: For some students wearing protective equipment made them feel like scientists. Others saw themselves as particular types of scientists, such as a chemist, or as an engineer. There were several who reported that they felt they embodied the characteristics of scientists, e.g., curiosity, throughout the project. In addition, some felt like scientists because they were benefiting the field and contributing something useful to society.

Research question 4: The Ghanaian teachers worked closely with the graduate students as they engaged the high school students in the biodigester project. They gained an understanding of the science of anaerobic digestion of food and livestock waste. They learned how projects like his can be implemented with simple materials. They also saw that it was helpful to choose topics that have applications that interest the students, like the environment and human health. In addition, they saw how their students responded when given the opportunity to have some control over the experiment and be creative.

Implications

This study demonstrates that it is possible to engage secondary students in authentic science activities using relatively simple materials, such as empty water bottles and plastic dishes, that are available to teachers and students in schools with limited resources. In addition, because these types of activities are atypical for schools in Ghana and in the US, it provides the students along with their teachers learning experiences that lead to outcomes that go beyond scores on high-stakes assessments. Finally, it helps make science concrete, rather than abstract.

Limitations

The limitations of the study include that it was implemented at only one school in one location, and that all the students were self-selected. Also, secondary education in Ghana is specialized right from the onset, and all the participating students were enrolled in the science specialization. In addition, we did not investigate effects of SES or gender on the students.

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