The Billion Oyster Project and Curriculum and Community Enterprise for Restoration Science Curriculum Impact on Teacher Engagement

Lauren B. Birney[1,*], Brian R. Evans[2], Joyce Kong[1], Vibhakumari Solanki[3], Elmer-Rico Mojica[4] & Christelle Scharff[5]

[1]School of Education, Pace University, New York, United States

[2]Dyson College of Arts and Sciences and School of Education, Pace University, New York, New York, United States

[3]NYC Department of Education New York, NY, United States

[4]Dyson College of Arts and Sciences, Pace University, New York, New York, United States

[5]Seidenberg School of CSIS, Pace University, New York, New York, United States

*Correspondence: 1 Pace Plaza, Pace University, New York NY, 10038. Tel: 01-212-346-1512. E-mail: lbirney@pace.edu

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Abstract

The Billion Oyster Project and Curriculum and Community Enterprise for the Restoration of New York Harbor with New York City Public Schools (BOP-CCERS) program is a National Science Foundation (NSF) supported initiative and collaboration of multiple institutions and organizations led by Pace University. The NSF project, Innovative Technology Experiences for Students and Teachers (ITEST), had generated a large amount of data through engagement with teachers and students throughout New York City public schools. This article presents the second part to a large data collection study with focus on Underrepresented Minority (URM) student interest in STEM and engagement with teachers to support them in teaching science through experiential learning and lessons that connect science to the real world, particularly through science in the New York Harbor. The first component of the study focused on URM student interest in STEM. This second component of the study focuses on teacher engagement in the program, and what the researchers had learned in the process. Overall, teachers reported very favorable options on the impact of the BOP-CCERS activities as ways to generate student interest in STEM majors and careers. Teacher participants were generally positive about the amount of support and resources they received as members of the project, as well as the oyster-related knowledge and practices they learned to use with their own students in oyster field research. Data from the study provided evidence that the teacher activities were successful and met the project's goals to provide support and resources for teachers to engage students in oyster restoration research.

Keywords: STEM education, STEM teachers, field research, engagement, motivation

1. Introduction and Background

The Billion Oyster Project and Curriculum and Community Enterprise for the Restoration of New York Harbor with New York City Public Schools (BOP-CCERS) program is a National Science Foundation (NSF) supported initiative and collaboration of multiple institutions and organizations led by Pace University. The NSF project, Innovative Technology Experiences for Students and Teachers (ITEST), had generated a large amount of data through engagement with teachers and students throughout New York City public schools. BOP-CCERS' model is one that involves over 5600 of New York City's 1.1 million public school students. This article presents the second part to a large data collection study (Birney et al., 2021b) with focus on Underrepresented Minority (URM) student interest in STEM and engagement with teachers to support them in teaching STEM through experiential learning and lessons that connect STEM to the real world, particularly through science in the New York City Harbor. The first component of the study focused on URM student interest in STEM (Birney et al., 2021b). This second component of the study focuses on teacher engagement in the program, and what the researchers had learned in the process.

2. Theoretical Framework, Literature Review, and Purpose

The theoretical framework for the second part of this study comes from Birney et al. (2021b), which is built upon Bandura's (1986, 1997) self-efficacy and social cognitive theory through which students develop through their social interactions and the development of their self-efficacy. For the second part of the present study, this foundation represents the framework in which teachers are engaged in preparation for teaching their students through an experiential learning and real-world problem lens that is designed to help students see the relevance, utility, and power of science in order to generate interest in STEM majors and careers.

As reported in Birney et al. (2021b), self-efficacy is one of the important variables for academic success, which is related to student engagement and persistence. Vygotsky's sociocultural theory of learning (Vygotsky, 1987) provides a framework for the study in which teacher facilitators and students form a community of learners through their collaboration and connections. The current project is framed through this community-building among teachers and students, and the project goal was to provide teachers with the tools necessary to connect STEM and the real-world through a community of learners.

The authors acknowledged that in order to increase Underrepresented Minority (URM) student participation in STEM courses, majors, and careers, it is important to provide students with real-world and engaging STEM activities (Birney et al., 2021b). The BOP-CCERS project provided teachers with the tools and experiences necessary to create opportunities for students to engage with hands-on and real-world STEM learning in the way that STEM professionals conduct their work. As indicated in another of the authors' publications, "Students learn science and mathematics through 'doing' in the way scientists and mathematicians conduct their own research, investigations, and practices (Brandt, 2016; Hoskins, 2019; Plank, 2017; Wilcox, Cruse, & Clough, 2015)" (Birney et al., 2021a, p. 29). Moreover, "Not only do these experiences reflect the way in which STEM professionals conduct their work, but also they can be some of the most engaging and rewarding of a student's academic career (Mokter Hossain & Robinson, 2012)" (Birney et al., 2021a, p. 29). In the first component of this present study, the authors investigated the impact of the BOP-CCERS STEM activities on student engagement and motivation with focus on engaging Underrepresented Minority (URM) students (Birney et al., 2021b). The second component focuses on the teacher engagement to empower and motivate students in their STEM studies.

Teacher professional development and engagement with the tools and experiences needed to engage their own students has the potential to improve student classroom learning, and in particular when those experiences model real-world STEM and engage students with activities that allow for inquiry (Buczynski & Hansen, 2010) and "doing" science as a student scientist (Gorghiu & Ancuta Santi, 2016; Tuss, 1996). In order to achieve these goals, professional development of science teachers is paramount (Abell, Appleton, & Hanuscin, 2007). Moreover, Roseler and Dentzau (2013) suggested that professional development for science teachers should be led by teachers given their education and classroom experiences. In this way, it is suggested that facilitators of professional development design activities through collaboration with teacher classroom needs, which are context based (Lumpe, 2007) and problem-based (McConnell, Parker, & Eberhardt, 2013).

The BOP-CCERS can also be thought of as project-based learning (PBL), that is one of the most frequently used strategies in science classes (Frank & Barzilai, 2004) and defined by Thomas (2010) as a model for organizing learning around projects. It can also be defined as an interdisciplinary student-centered activity with well-defined project outcomes (Han et al., 2015). PBL features student autonomy, constructive research, goal setting, collaboration, communication, and reflection in real-world practice (Kokotsaki et al., 2016), which also reflects the BOP-CCERS process. The barriers commonly associated with PBL, such as teachers' hesitancy in using student-directed instruction (often perceived as loss of classroom management) and practical study-based education, are overcome in the BOP-CCERS program through activities related to professional development. The PBL approach has been shown to provide inexperienced teachers with a diverse and valuable learning experience and support their professional and personal growth. (Tsybulsky & Muchnik-Rozanov, 2019). Working within a team at BOP-CCERS, allows teachers to exchange knowledge and skills in a variety of subjects, leading to a transition from "expert learner" to "expert" (Almulla, 2020). This PBL process has the potential to develop teachers for leadership (King & Smith, 2020).

Specifically, the foundation for the *Framework for Engagement with Mathematics* (FEM) established by Attard (2014) outlines a tool to analyze teaching and learning to assist teachers in planning and engaging learning experiences in mathematics. FEM outlines student engagement in two separate but interrelated elements: pedagogical relationships and pedagogical repertoires. The former highlights the interpersonal teaching and learning relationships that optimize learning and the latter, the teaching practices employed in day-to-day teaching (Attard et al., 2021). The authors suggest the development of positive pedagogical relationships provides an important foundation on engagement that is

necessary for substantive, sustained engagement, incorporating operative, cognitive, and affective domains. Engagement in STEM subjects is enhanced by promoting student enjoyment and making clear connections with students' lives (Ainley & Ainley, 2011).

The purpose of the current study was to engage with middle and high school science teachers to assist them in using project-based learning and real-world data collection in their classrooms with their students through harbor restoration initiatives (Birney et al., 2021b). This engagement provides tools, experiences, and resources for teachers to engage their own students in the STEM process and hence more authentic learning experiences. Moreover, the study serves as a model of how a place-based curriculum can be used to enhance both teachers' and students' understanding and appreciation of the interrelationships in their local ecosystems by engaging all classroom stakeholders in ongoing field research and stewardship activities.

3. Methodology

The design of the larger study (see Birney et al., 2021b) was through survey research conducted by the National Science Foundation (NSF) grant-funded research and evaluation firm, The Mark, which serves as a consultant for the NSF project, Innovative Technology Experiences for Students and Teachers (ITEST). Moreover, Gaylen Moore Program Evaluation Services served as a consultant to conduct program evaluation on the teacher participants in the project. This was largely done through survey and observational data collection methods.

The purpose of the second study was to engage with middle and high school science teachers to assist them in using project-based learning, real-world data collection equipment and field research skills in their classrooms with their students through harbor restoration initiatives. This engagement provides tools, experiences and resources for teachers to engage their own students in the STEM process and hence more authentic and engagement learning. Teachers were surveyed on their experiences in the program through two survey instruments: Year-End Teacher Survey and Professional Learning Participant Survey.

The BOP CCERS Digital Platform was used in this study and serves as the central technology hub for the BOP-CCERS Project (https://bopuiprod.azurewebsites.net/). Information on the Digital Platform including the following: Data and Research conducted by the project team, teachers, scientists and students, events and activities supporting the current research, symposia, trainings and forums, curricula, materials and resources to support teachers in the classrooms, STEM laboratory classroom guides, NY Harbor species identification guides and reporting of project information for the National Science Foundation. The BOP-CCERS platform team researchers, teachers, and staff have contributed to developing 18 units that include 145 lessons and have taught 1,869 students in New York City Schools. Teachers can access the platform for inquiry-based curriculum on restoration science and download and provide feedback on lessons. This platform allows for interactions on a local, national and global scale for STEM industry professionals to communicate, share data with teachers and students and provide access for international collaborations (Figure 1).

Figure 1. Digital Platform

Students are also able to share their annual research as depicted in the following research symposia held annually on Governors Island.

Figure 2. Annual Student Research Symposium

Sample student projects can be found here: https://www.billionoysterproject.org/2021-symposium-projects. Previous projects can be viewed here as well: https://www.flickr.com/photos/nyhf/albums/72157718172389121

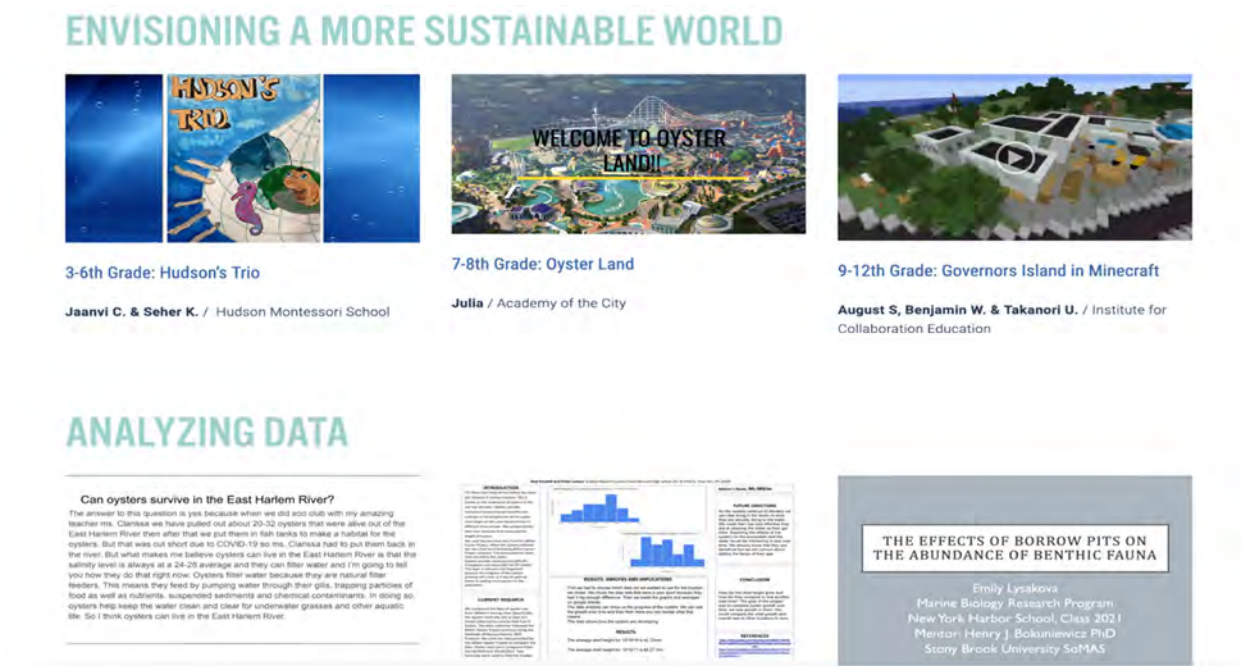
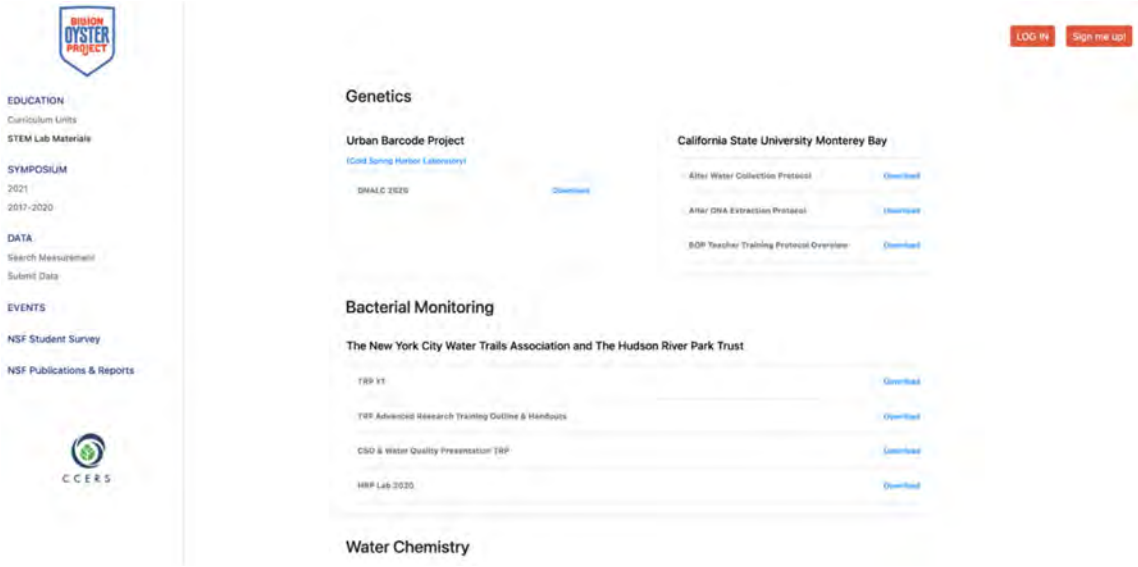


Figure 3. Sample Student Research Projects

Additionally, units of study for teachers are available to download and use in their classrooms. These resources provide information pertaining to global sustainability, environmental restoration science and engineering and design.



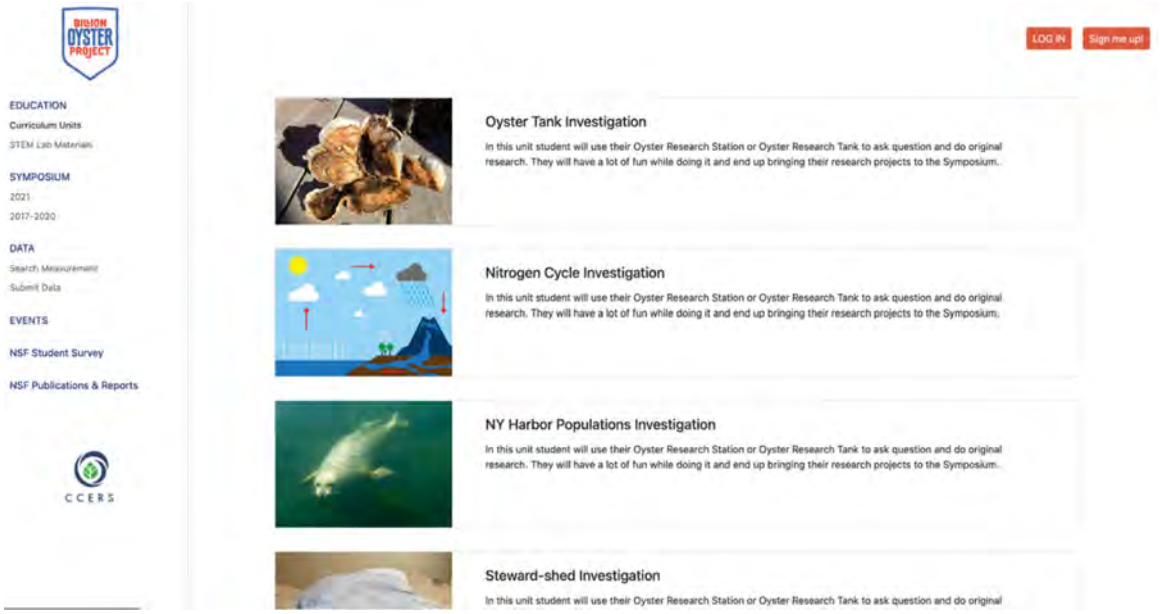


Figure 4. STEM Curriculum

Ultimately, it is anticipated that this digital platform designed in conjunction with Fearless Solutions and Morgan Stanley will serve as a dynamic technology component that allows for researchers and scientists to communicate on a "real time" basis and allows for students and teachers to collaborate, interact and learn from one another's communities on a global scale. The vision is that the data collected and validated in the platform by pupils, teachers and citizen scientists during expeditions can be further used for analysis and research purposes. A rich amount of data collected to date includes: dates, locations, live oyster population counts, oyster sizes and weights, water quality, water pH, weather and tide conditions, and photos of Oyster Restoration Station conditions. These data sets have been used by middle school and high school students in their annual symposium research and during the Summer STEM Institutes where high school students use python and data science to analyze the data.

Figure 5. Field Research at an Oyster Restoration Station

4. Results

Observational data collection and analysis of the 12 BOP-CCERS professional learning activities revealed high-quality professional learning opportunities for teachers had taken place, and the majority of interactions were identified as characteristics of high-quality facilitation on the project. The 12 activities involved professional development sessions on harbor restoration and science including the Oyster Restoration Station (ORS), ocean engineering, inquiry-based learning, and biodiversity.

4.1 Year-End Teacher Survey

The Year-End Teacher Survey was used to collect data in June, 2020, and was completed by 51 teachers. Results revealed teachers were positive about the amount of support and resources in the project, as well as the New York Harbor restoration knowledge and practices they learned in BOP-CCERS professional learning activities. The majority of teachers reported the development sessions enabled them to promote student engagement, student learning, and interest in STEM careers. Teachers were most positive about the extent to which the BOP-CCERS activities increased their own awareness of what is happening with teaching activities related to New York Harbor restoration.

Moreover, teachers particularly expressed appreciation for learning how to use the Oyster Research Station (ORS), and they were most positive about the extent to which the preparation and activities had increased their own comfort level with being around the waterfront and conducting field research with students. ORS allows participants to work directly with New York Harbor restoration through nurturing the oysters at the ORS to restore the harbor.

In addition, teachers expressed feeling more confident engaging with students in field science and research after participating in ORS activities than they did prior to participation. ORS teacher participants had positive responses to statements about the impact of BOP in increasing their awareness of oyster restoration in New York Harbor, increasing their comfort level with field research, and guiding students in field research. It should be noted that this aligns well with previous research indicating learning is best conducted when students "do" science in the way scientists conduct science (Brandt, 2016; Hoskins, 2019; Plank, 2017; Wilcox, Cruse, & Clough, 2015).

Of particular note in the survey results was the agreement among teacher participants with the statement, "I feel I can contact BOP staff for field research, classroom resources, and/or support to implement BOP activities with my students." Moreover, teachers agreed, "My experience in BOP has increased my awareness of what is happening with oyster restoration in New York Harbor" and that a benefit was to "increase my own comfort level with being around the waterfront and conducting field site research with my students."

4.2 Professional Learning Participant Survey

The Professional Learning Participant Survey was used to collect data from the teachers following their participation in BOP-CCERS professional learning activities related to science and harbor restoration, and was completed by 70 teacher participants. The data provided evidence that these sessions were successful and met the project's goals to provide support and resources for teachers to increase student engagement and learning in oyster restoration research, and interest in STEM careers. The facilitation of ongoing participation in professional learning had given teachers opportunities to learn and troubleshoot collaboratively with other teachers across New York City and more resources for engaging their students and new ways to build STEM engagement and interest in their classrooms and with their students.

Of particular note in the survey results was the agreement among teacher participants with the statement, "I increased my knowledge of STEM concepts and content related to restoration science and BOP-CCERS." Moreover, teachers responded positively to the following statement, "I received the resources necessary to carry out this lesson or activity with my students." This reflects well on the work from Tsybulsky and Muchnik-Rozanov (2019), which had indicated that project-based learning (PBL) has the potential to provide learning experiences that support their professional and personal growth.

5. Discussion and Conclusion

The results of the study were promising. The evaluation findings of the project indicated that creating explicit content that connects students to careers, including those beyond lab scientists, is an area in which BOP-CCERS can expand by being more explicit in promoting student awareness of doing scientific work and linking students' research projects to the pursuit of a STEM career. Additionally, it was found that teachers particularly expressed appreciation for learning how to use the Oyster Research Station (ORS), which demonstrates the project's approach to experiential learning with the teacher participants has potential to impact the views of teachers on using experiential models with their own

students.

Overall, teachers reported very favorable options on the impact of the BOP-CCERS activities as ways to generate student interest in STEM majors and careers. The most favorable response among all participants was to the statement: "My students were acting as scientists and recognized that it was possible for them to become scientists." This is promising as it demonstrates that teachers gained confidence with engaging their students in authentic STEM activities that allow students to function like scientists as they explore and engage in inquiry-based learning, which better prepares them for "doing" science in future study and careers. This aligns with previous work in this area that learning is best conducted when students are actively involved in their learning through inquiry approaches similar to how science is conducted in the field (Brandt, 2016; Hoskins, 2019; Plank, 2017; Wilcox, Cruse, & Clough, 2015).

Teacher participants were generally positive about the amount of support and resources they received as members of the project, as well as the oyster-related knowledge and practices they learned to use with their own students in oyster field research. Teacher participants were most positive about the extent to which the BOP-CCERS activities increased awareness of local ecology and oyster restoration in the New York Harbor. As indicated early, this aligns well with the work by Tsybulsky and Muchnik-Rozanov (2019), who documented the potential that project-based learning (PBL) has for supporting professional and personal growth.

Overall, data collected from teacher participants following their participation in BOP-CCERS professional learning activities provided evidence that these sessions were successful and met the project's goals to provide support and resources for teachers to engage students in oyster restoration research. The findings suggest that promoting ongoing participation in professional learning gives teachers more confidence and resources for engaging students and new ways to build interest in STEM careers.

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