The Billion Oyster Project and Curriculum and Community Enterprise for Restoration Science Curriculum: The Digital Platform and Student Symposium Presentations

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Received: July 1, 2022 Accepted: September 1, 2022 Online Published: October 19, 2022

doi:10.5430/jct.v11n8p53 URL: https://doi.org/10.5430/jct.v11n8p53

Abstract

The Billion Oyster Project and Curriculum and Community Enterprise for the Restoration of New York Harbor (BOP-CCERS) program is a National Science Foundation (NSF) supported initiative and collaboration of multiple institutions and organizations led by Pace University and is in collaboration with New York City Public Schools. This large-scale project, Innovative Technology Experiences for Students and Teachers (ITEST), generated a large amount of data through programming that engaged both teachers and students. This article presents the third part to the study with focus on the Digital Platform and results from the student Symposium presentations. Part 1 focused on Underrepresented Minority (URM) student interest in STEM as motivated by the original project. Part 2 focused on URM student engagement with teachers to support students in teaching science through experiential learning and lessons that connect science to the real world, particularly through science in the New York Harbor. Moreover, the second part of the study focused on teacher engagement in the program, and what the researchers had learned in the process. The third aspect of the study, and primary focus on this paper, had found additional positive results cited by the teachers in the study both using the Digital Platform and after the project outcomes from the student Symposium presentations.

Keywords: STEM education, experiential learning, digital platform, symposium

1. Introduction

1.1 Aim of the Research

The Billion Oyster Project and Curriculum and Community Enterprise for the Restoration of New York Harbor (BOP-CCERS) program is a National Science Foundation (NSF) supported initiative and collaboration of multiple institutions and organizations led by Pace University and is in collaboration with New York City Public Schools. This large-scale project, Innovative Technology Experiences for Students and Teachers (ITEST), generated a large amount of data through programming that engaged both teachers and students. The BOP-CCERS' model engages over 5600 of New York City's 1.1 million public school students. This article presents the third part to a large data collection study (Birney et al., 2021b, 2022) 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 Underrepresented Minority (URM) student interest in STEM (Birney et al., 2021b). The second component of the study focused on teacher engagement in the program, and what the researchers had learned in the process (Birney et al., 2022).

The purpose of the current study was to supplement parts 1 and 2 with a focus on the Digital Platform and results from the student Symposium presentations. The Digital Platform serves as the central technology hub for the BOP-CCERS program. Information on the Digital Platform includes 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 NSF" (Birney et al., 2022, p. 55). The concept supporting the Digital Platform is to develop a tool for teachers and students to gather and analyze oyster restoration field data. Moreover, it is to provide resources for teachers and students to use within their research projects. The Digital Platform is a collaboration with BOP-CCRES teachers and staff, Fearless Solutions, and Morgan Stanley.

The Digital Platform serves 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" (Birney et al., 2022, p. 58). Data collected and validated in the platform by students, teachers, and citizen scientists can be used for future analysis and research purposes. Currently, there is a rich amount of data in the platform with information such as date, location, number of live oysters, oyster measurements and weights, water quality, water PH, weather and tide conditions, and photographs. As an example, these data have been used by students in their research for the Symposium in which students conduct data analysis using Python.

A major highlighted event for the project was for students to participate in a final presentation Symposium and use the Digital Platform to conduct their research and work in June 2021. Every year BOP-CCERS hosts a Symposium, which is an opportunity for students from across New York City to showcase their research, learning, and projects related to their local waterways. The first Annual BOP Research Symposium was held in June 2015 as part of a National Science Foundation project involving teacher training, student curriculum, field science and student research based on the BOP-CCERS oyster restoration work in New York Harbor.

The presentations were conducted virtually due to the pandemic, but have returned in-person on Governor's Island in 2022. Despite the limitations set by the pandemic, there were 124 student projects that were developed by 213 students. There were 16 teacher facilitators and 33 guest judges (composed of educators and scientists) for the presentations, and each student presentation was 30 minutes long.

Teachers in the BOP-CCERS program were surveyed about various aspects of their participation, such as their professional development, teaching harbor restoration, and methods for engaging their own students. Three surveys were used to determine areas of success in the project such as teacher engagement with the project, success of the Symposium, and an end of year summative evaluation of the project.

1.2 Theoretical Framework and Literature Review

The theoretical framework for the third part of this study comes from Birney et al. (2021b, 2022), which is built upon Bandura's (1986, 1997) self-efficacy and social cognitive theory. Student development occurs through social interactions both between student and student and teacher and students, and this impacts the development of their self-efficacy. As reported in Birney et al. (2021b and 2022), self-efficacy is one of the important variables for academic success and relates to student engagement and persistence. Vygotsky's sociocultural theory of learning (Vygotsky, 1987) provided a framework for the larger study in which "teacher facilitators and students form a community of learners through their collaboration and connections" (Birney et al., 2022, p. 54). The third part of this project is also framed through this community-building among teachers and students as was found in the first two parts to the larger study.

The foundation for the three part study rests upon providing students with real-world and engaging STEM activities while providing professional development for teachers in order to provide students with these engaging real-world experiences (Birney et al., 2021b, 2022). Moreover, the project is designed to provide the teachers with tools needed for hands-on and real-world STEM learning in the way in which STEM professionals conduct their work.

As indicated in the first part of the study, "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 it was said that "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). The literature provides support for conducting science in the way that scientists do (Gorghiu & Ancuta Santi, 2016; Tuss, 1996) and engaging students in real-world learning (Buczynski & Hansen, 2010). Moreover, previous studies support success using experiential learning with students from underrepresented groups (Anderson & Coleman-King, 2020; Beauchamp, Robers, & Aloisio, 2021; Hernandez, Donnelly-Hermosillo, Person, & Hansen, 2021). Teachers can learn to teach with this approach through professional development that is context and problem based (Abell, Appleton, & Hanuscin, 2007; Almulla, 2020; Lumpe, 2007; McConnell, Parker, & Eberhardt, 2013; Roseler &

Dentzau, 2013). Moreover, a project-based approach that engages students has the potential to create an environment in which students enjoy and connect with the content learned (Ainley & Ainley, 2011).

Problem-based learning demonstrates positive results in self-efficacy, self-confidence, and interest in learning, suggesting that hands-on learning and field-based experiences increase content knowledge for learning (Nava & Park, 2021). Implementation of real-world learning for STEM skills through problem-based learning enhances creativity and innovation. This promotes and supports the utilization of critical thinking, reviewing research, creative thinking in problem-solving, and synthesizing information (Widiyanti et al., 2020).

In addition to doing science, the Digital Platform and student Symposium can serve as scientific conferences to give young students opportunities to present their results. There are many advantages for students presenting their results in scientific conferences. At such a young age, it is really good training for students to be exposed to this kind of experience. An array of advantages can be gained from such an experience. Among them are increased confidence related to participation in science and scientific research; thinking and working like a scientist and improving communication skills, clarification, confirmation and refinement of career path, changes in attitudes toward science and learning, among others (Seymour et al 2004). In addition, science teachers actively engaged with their students in research can transition from science teacher to 'teacher scientist', which has a multifaceted role of teacher, researcher, coach and mentor (Rushtone et al 2019).

2. Methodology

The design of the larger three-part study (see Birney et al., 2021b) was done through survey research and interviews conducted by a National Science Foundation (NSF) grant-funded evaluation firm, The Mark. The Mark has been serving as the consultant on the larger Innovative Technology Experiences for Students and Teachers (ITEST) project, which is supported by the NSF. For the data obtained on all three parts of the study, Gaylen Moore Program Evaluation Services has been serving as a consultant for program evaluation on the teacher participants through survey and observational data collection. The purpose of the third study was to provide information on the Digital Platform, which is the BOP-CCERS central technology hub for the project and also to provide results from the student Symposium that was conducted virtually in June 2021.

Survey research and interviews were used to determine how well the project work did in supporting teachers and STEM professionals, scientists, and mentors to motivate students in developing interests, skills, knowledge, and career awareness in harbor restoration science. First, a Professional Learning Survey was used to collect data from teachers involved in the project, which measured teacher engagement in the project. There were 98 teacher responses to the survey out of 158 teachers who were asked to complete the survey.

Second, the 16 teachers in the Symposium were surveyed on their experiences using a satisfaction survey on their experiences in the Symposium. Two teachers responded to the survey, which represents a very small number of the teachers involved. This represented work done with 213 students for 124 projects and involved work with 33 guest reviewers. A limitation of the study is the very low response rate for this survey instrument.

Finally, the Teacher Retrospective Survey was used to measure the extent and nature of teacher and student participation at the end of the year for the project. There were 19 teachers who responded to the survey, and 13 were used to gather data, out of 135 surveyed. Six of the responses were not included since they were not as actively involved in the project as the 13 teachers.

3. Results

Results of the Professional Learning Survey revealed that teachers generally indicated an increase in content knowledge as related to oyster restoration lessons through participation in the program (67 of the 98). Moreover, teachers gained strategies for encouraging student interest in pursuing STEM career pathways (59 of the 98), and learned how to better promote student understanding on active stewardship for the environment (58 of the 98). It was found that 87 teachers indicated they planned to use these materials in their own classrooms, while 89 teachers indicated that these activities can increase awareness in STEM careers for their students.

Results from the Symposium survey were positive with teachers most commonly citing an increase in knowledge in data science and concepts. The teachers responded that they plan to use the activities developed in the Symposium in their classrooms, and that student engagement in the project was high. The hands-on nature of the activities were cited by the teachers. Teachers indicated that student participation in the Symposium enabled students to learn about scientific research and STEM careers. Moreover, teachers reported students had the ability to choose the type of project they created, which allows for more student engagement, and were able to collect data for their projects along with using data provided by the Digital Platform. Again, a major limitation was the low response rate of only two teachers to this survey instrument. Results from this instrument should be interpreted with caution.

Teachers also indicated that students' research projects increased their knowledge about oyster restoration. Teachers provided suggestions about aspects of the virtual Symposium that they would like to continue when the Symposium returns in-person in the future. One teacher said, "The timing of the BOP Symposium is usually during the end of the year when there are many events at school so sometimes in the past it coincides with a school event. This year since it is virtual, we don't have to worry about logistics."

The Teacher Retrospective Survey was used to measure the extent and nature of teacher and student participation in the Symposium. It was found that 38 percent of teachers responding indicated they facilitated student use of oyster restoration research projects and 40 percent of them had students present at the Symposium. Findings from this study revealed that all respondents used their participation in the project as a way to teach their students about harbor restoration and ecology, and some used it as an entry to students' own scientific research and endeavors. Moreover, most respondents reported that activities facilitated teachers' abilities to develop students' interest in STEM careers. Respondents rated the item indicating staff support and resources provided for the project to be high. Moreover, respondents indicated increased awareness on how to engage their students in experiential learning such as harbor restoration. Respondents reported high levels of confidence and resourcing to implement BOP methods in their own classrooms.

3.1 BOP-CCERS Digital Platform

The BOP-CCERS Digital Platform, https://bopuiprod.azurewebsites.net/home, serves as a repository of data, research, materials, and resources generated by the support provided by the National Science Foundation in NSF EHR DRL Grants 1839656 and 1759006/Principal Investigator, Dr. Lauren Birney. The mission is to provide information on a global scale to stimulate networks and communities in Environmental Restoration Science to connect and communicate with one another, as shown in Figure 1.

Figure 1. Our Mission

Environmental Science Curriculum is available for teachers, students, faculty, community members, and citizen scientists to access (see Figure 2).

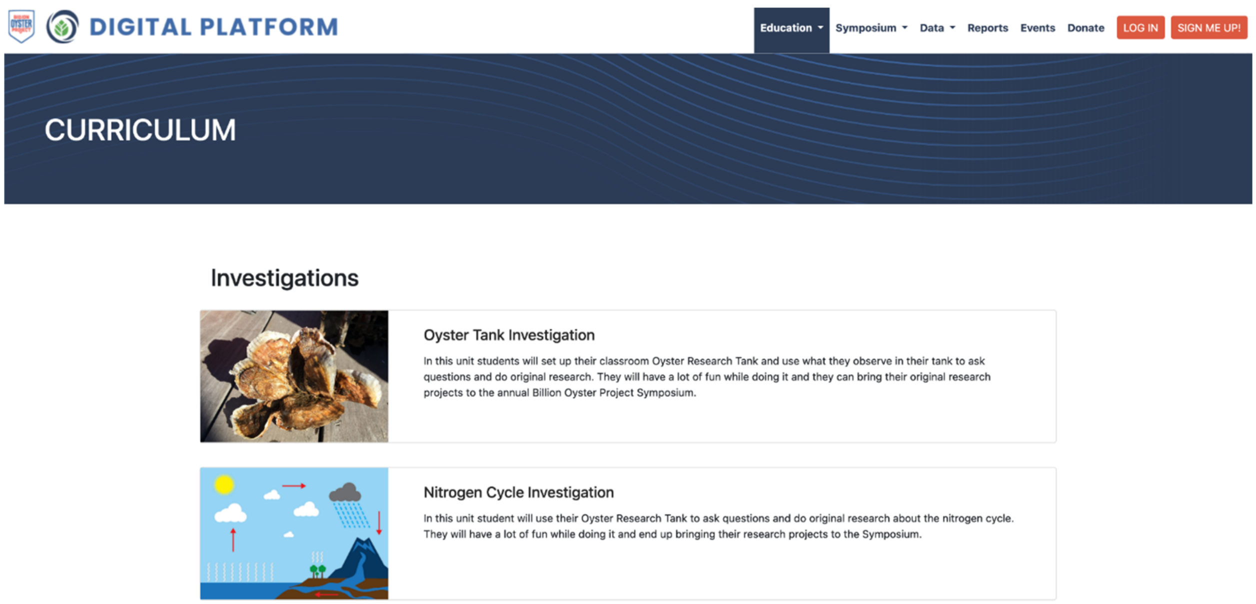

Figure 2. Curriculum

Events, Colloquia, Symposia, and activities also provide opportunities for connectivity, accessibility and networking globally among related communities (see Figure 3).

Figure 3. 8th Annual BOP Student Symposium

Publications, reports, grant activity, partnerships, and strategic plans can also be found within the Digital Platform. This provides access for communities to engage further in the work and research taking place on the projects (see Figure 4).

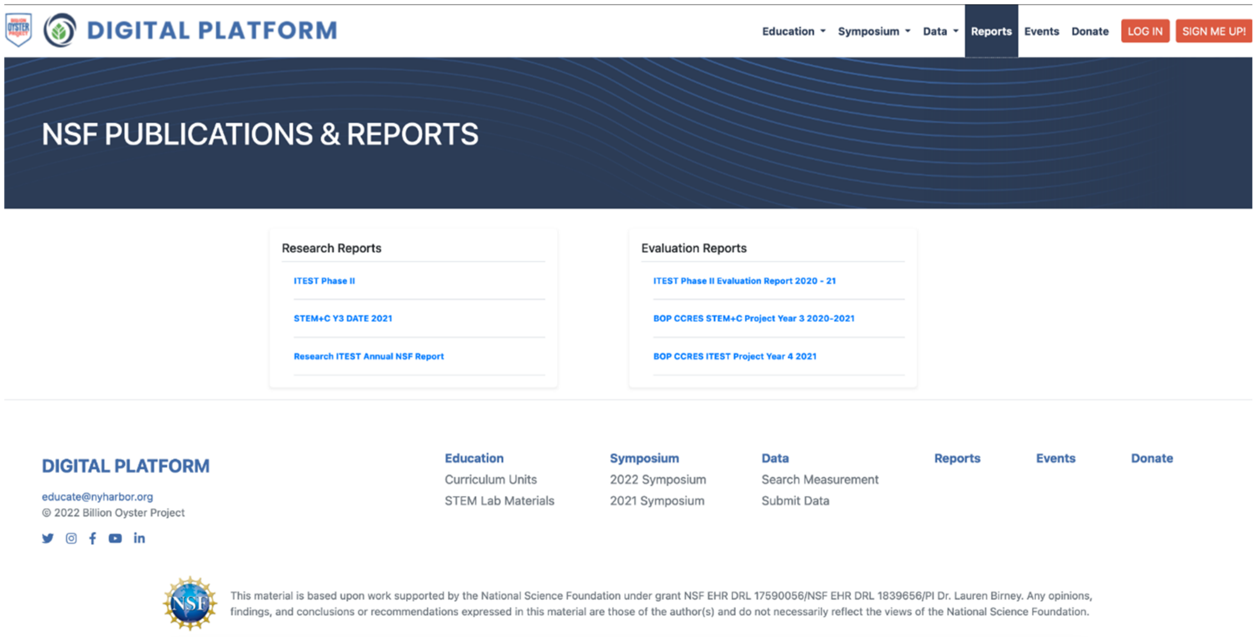

Figure 4. NSF Publications & Reports

Virtual and remote activities may also be accessed (see Figure 5).

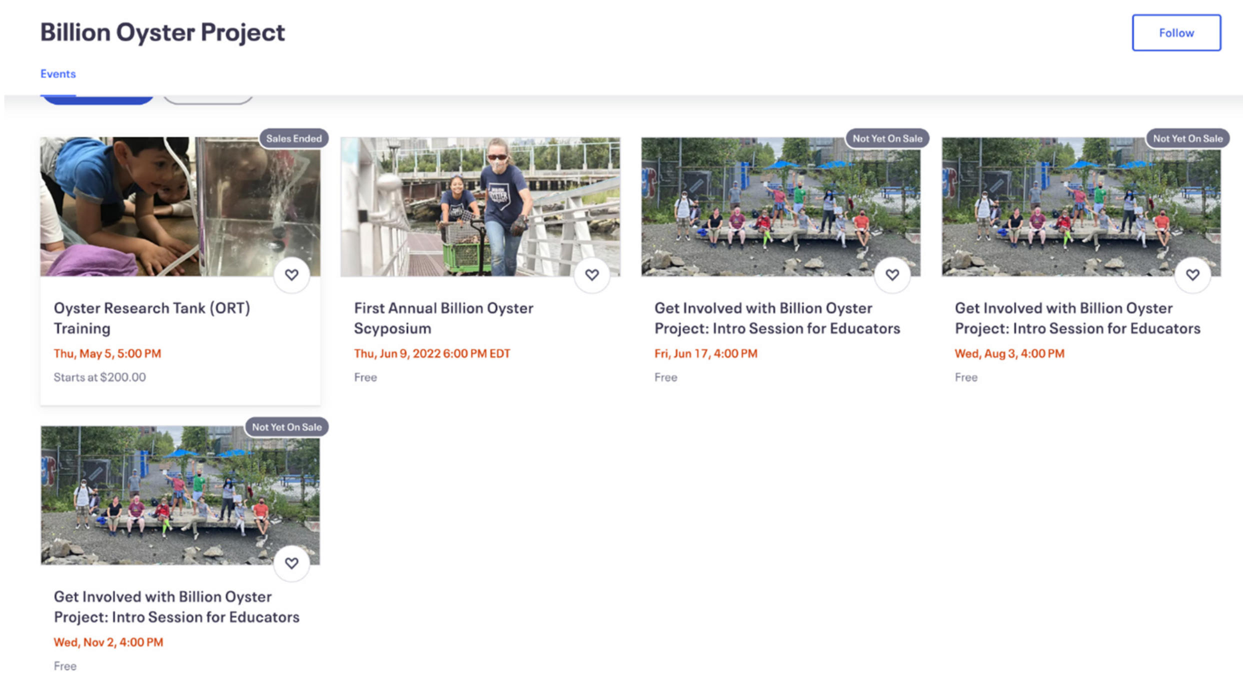

Figure 5. Billion Oyster Project Events

Ultimately, the BOP-CCERS Digital Platform serves as the central technology hub for all partners and stakeholders to access, engage in events and activities, and network together in a common mission for providing clean water to New York Harbor. We also have project media that provide opportunities for the community to view the students in action, and found at. https://stemforall2022.videohall.com/presentations/2269 (see Figures 6 and 7).

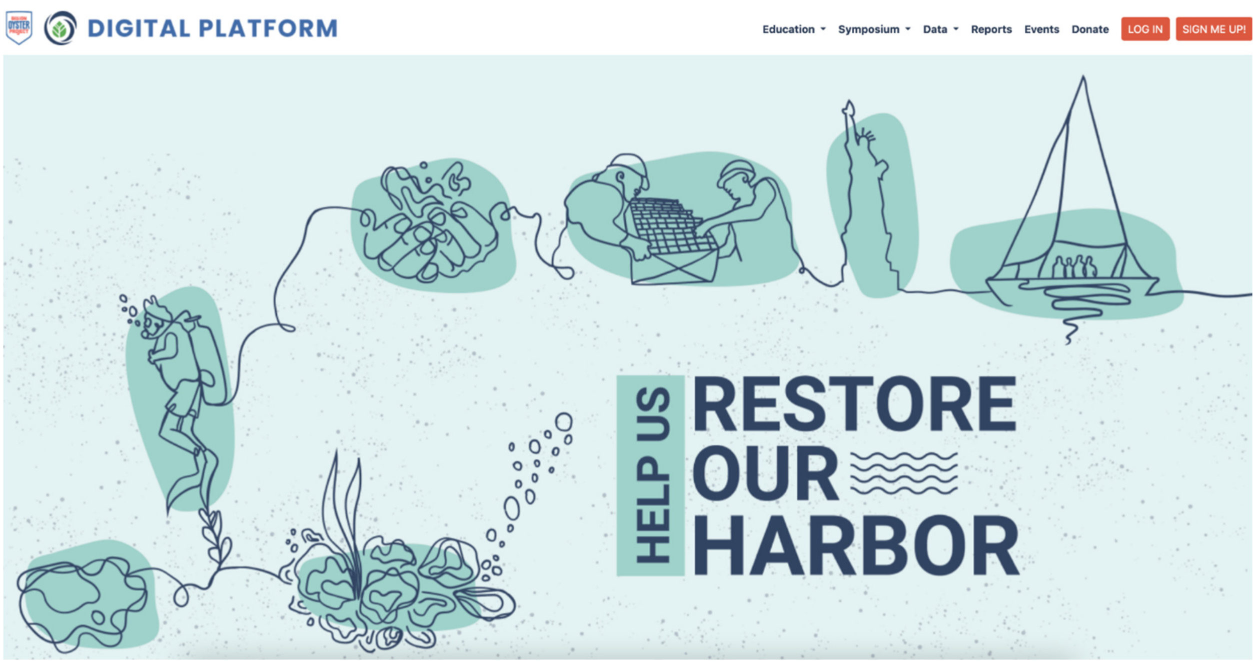

Figure 6. Help Us Restore Our Harbor

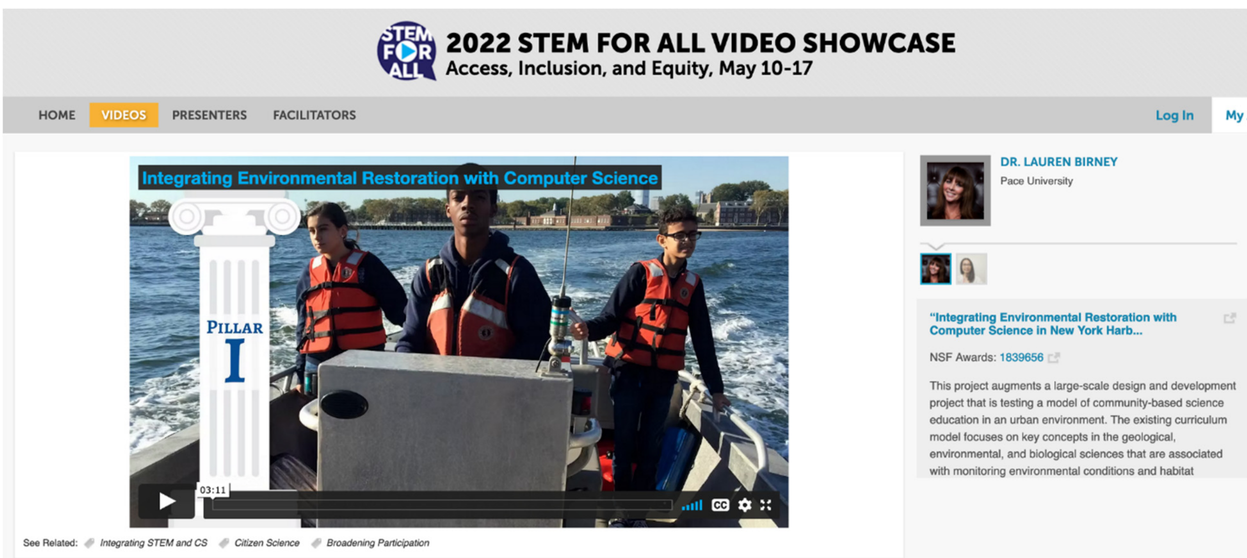

Figure 7. 2022 STEM for All Video Showcase

3.2 Overall Analysis for the BOP-CCERS Project Participation

Statistical analyses were conducted by The Mark on the larger BOP-CCERS project looking at student participants who participated in BOP-CCERS activities (*n* = 423) against those who did not (*n* = 90). A Variance Inflation Factor (VIF) was used to determine if there were differences in student scientific identity and career interest in STEM fields by grade level (9, 10, 11, or 12th grade) and sex. It was found that 11th grade students who participated in BOP-CCERS activities had higher levels of scientific identity compared to 9, 10, and 12th grade students in either participant group. It was found that 9th grade students who participated in BOP-CCERS activities had higher levels of STEM career interest compared to the 10, 11, and 12th grade students in either participant group. Moreover, when it was found that 9th grade female students also had higher levels of STEM career interest compared to female students in any other group.

4. Discussion

The authors were encouraged by the results obtained from the expansion of the Digital Platform and the results of the data collected on the student Symposium presentations in June 2021. Despite the limitations from the pandemic, the longer term project, and in particular Symposium, was a success with positive outcomes indicated by the teachers involved. Again, a limitation was the small percentage of teachers who completed the post-Symposium survey, and additional techniques to improve response rates will be needed for future teachers engaged in the Symposium.

Results indicated that real connections between the project and classroom teaching were made, and the study provided additional evidence on the value of experiential and hands-on science learning (Brandt, 2016; Hoskins, 2019; Plank, 2017; Wilcox, Cruse, & Clough, 2015). Moreover, not only did students engage with the project, but the professional development aspects of the project helped the authors better understand how these experiences can be connected directly to classroom instruction. Further study needs to be conducted on the follow through with the teachers in order to determine to what extent and in what ways the results are integrated into changed and better classroom instruction.

Results from the overall BOP-CCERS project revealed groups that may benefit most as targeted by the project such as students in 11th grade or female students in 9th grade. Future project implementation could focus on these groups in particular to see if the greatest impacts are being sustained with these subsets of the project. Moreover, future longitudinal studies should measure the duration of such changes and determine what supports may be necessary to sustain these levels.

Recent experiential learning interactions have indicated the lasting impact of projects such as this one. For example, one of the authors leads chemistry research projects with undergraduate students. Early results indicated that involving them in undergraduate research has given them authentic research experiences and helped them better understand and practice science. By presenting at conferences and publishing their work in research journals, they have improved their communication skills, gained knowledge about their research topic, and gained the opportunity to network with others (Farshi et. al, 2021)

The digital platform and student symposium presentations are good venues to prepare future students on how to "do science" and develop their skills in communications. It also allows science teachers who mentor these students to be transformed into teacher scientists.

5. Conclusion and Implications

The results from the project implementation and study indicate that experiential learning has the potential to increase teacher knowledge and ways to generate student interest in STEM careers. Moreover, this project had enabled teachers to generate interest among students in protected our environment, particularly around harbor restoration. Use of the Digital Platform enabled teachers and student to use real data in a way that engages students in the scientific process in ways that scientists operate, which is a best practice in teaching science (Brandt, 2016; Hoskins, 2019; Plank, 2017; Wilcox, Cruse, & Clough, 2015). This approach aligns with the literature in order to provide support for student learning in the manner in which scientists conduct their work (Gorghiu & Ancuta Santi, 2016; Tuss, 1996) along with supporting underrepresented student learning through experiential learning (Anderson & Coleman-King, 2020; Beauchamp, Robers, & Aloisio, 2021; Hernandez, Donnelly-Hermosillo, Person, & Hansen, 2021).

Generating student interest in STEM careers and environmental protection has broad implications for future STEM professionals and critical protection of our environment. An important implication for future implementation is to sharpen the focus on 11^{th} grade students and female 9^{th} grade students, in particular, given the greatest impacts found here. Future implementation of this project should focus on these areas, and research should continue to confirm the ideal grades for implementation. While this project was funded by the NSF, future projects could be conducted by other researchers and practitioners on a smaller scale for cases in which funded is more limited.

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