The Curriculum and Community Enterprise for Restoration Science (STEM + C): Blending Social Justice Engagement with Academic Instruction to Help Pique Student Interest in Environmental Restoration and Urban Renewal

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Abstract

A major blight of urban development has been the existence of environmental inequities which affect how and where low-income communities and communities of color live. Targeted communities are beginning to receive long-overdue analysis and civic action. New laws and amendments have been made to better the conditions of these historically underserved communities. Currently, in New York City, historic progress is being made by providing all residents of these affected communities with the tools to advocate for the best outcomes for their neighborhoods. It is the first time in the city's history that the issue of environmental justice has reached such a milestone. Civic participatory action of this magnitude requires the development of alliances between all members of the community. Students from these marginalized neighborhoods can make a vital contribution in eliminating environmental racism and restoring their communities' environmental urban footprint. To this end, the Curriculum and Community Enterprise for Restoration Science (STEM + C) Project has been working to provide long-term, hands-on, environmental restoration education and action research to the students in New York City. Restoration of the Eastern oyster in New York Harbor waterways surrounding many of these communities exposes the youth of the city to the community inequities. One of the objectives of the CCERS STEM + C Project is to study its effect on student awareness, motivation and engagement in community-based environmental restoration. Over 500 New York City school students were surveyed on self-reported factors including awareness, motivation and community engagement. Those students in the CCERS STEM + C Program had a significantly higher level of awareness and motivation in terms of community-engagement and social action.

Keywords: social justice, environmental restoration, urban restoration, community-based learning

1. Introduction

1.1 Introduce the Problem

On Election Day, 2022, the Environmental Bond Act was approved by voters in New York State. Although previously approved in the 2020 budget, the funding was eliminated due to the COVID crisis (Cherson, 2022). Renamed the "Clean Air, Clean Water, and Green Jobs Bond Act", much of the funding is earmarked for mitigating the effects of existing and future climate change impacts. However, a substantial portion, approximately 35% of the funding, is reserved for environmental justice communities. A relatively new term, environmental justice communities are those defined as communities of low-income people and people of color who are exposed to poor air and water quality, detrimental land uses and infrastructure, and noise at rates that exceed those expected based on their portion in the general population (Mohai, Pellow & Roberts, 2009). In tandem with the Environmental Bond Act is the Environmental Rights Amendment, also called the Green Amendment, which took effect in New York on January 1, 2022 (Halliday et al., 2021). New York's Green Amendment has a further objective of adding protections against environmental racism. The codification of New York's "green amendment" creates a safety net for future environmental protections by guaranteeing New Yorkers “a right to clean air and water and a healthful environment” (New York Constitution, 2022).

The importance of this issue is paramount. The institutional regulations, policies, or government decisions that deliberately target Black and Brown communities for placement of major sources of pollution are known as environmental racism. Based on the limited enforcement of zoning and environmental laws, these neighborhoods are earmarked for locally undesirable land uses and are excessively exposed to hazardous toxins. This social inequality directly impacts health and mortality rates (Cushing, Morello-Frosch, Wander & Pastor, 2015). To assess environmental equity issues and develop a plan to incorporate environmental justice into the fabric of the city decision-making, New York City passed Local Laws 60 and 64 in 2017. This legislation centers on three main products: a report, an online Environmental Justice portal, and a plan. This legislatively mandated work, known as Environmental Justice New York City (EJNYC), represents a historic investment from the City of New York to study environmental inequities affecting low-income communities and communities of color. Further, tools were provided to all the residents, enabling civic advocacy for their communities. It is the first time in the city’s history that the issue of environmental justice has reached such a milestone.

The engagement of all of the major players in the affected communities bolsters efforts to concatenate these separate but related turning point events. The corporate world and philanthropic associations will quickly get behind this movement and in fact, some have spearheaded this sequence of events. One vital group of advocates that has a major stake in the outcome of these new laws is the youth of these disenfranchised communities. Getting youth involvement in community-based, social justice issues, especially students from low-income and marginalized neighborhoods and populations is a crucial step in attaining environmental social justice and combatting environmental racism. Modern pedagogical concepts have risen in the past decades to address the demand for connecting students’ interests with science learning in a critical manner, such as culturally responsive science teaching (Ashbrook, 2021) and justice-centered science pedagogy (Morales-Doyle, 2017). Rooted in critical pedagogy (Freire, 1970), in which the oppressed become liberated by becoming an active voice in their education, helping to ameliorate social injustice through experiential learning and thoughtful engagement (Mitchell & Chavous, 2021). Teachers are not knowledge gatekeepers who transfer knowledge within the walls of a school classroom but rather mentors (Bruner, 1985) connecting students to their real-life experiences in the community and encouraging students to take ownership of the process of learning science (Hanewicz, Platt & Arendt, 2017). Most disengaged learners draw from critical race theory (Delgado & Stefancic, 2017), which highlights the validity of personal experiential knowledge. Students’ social capital and sense of civic engagement can be strengthened through direct contact with the environmental factors that are being investigated (Dolan, 2022).

Community-based learning (CBL) has been the prime means to provide students with education and experiences that prepare them for thoughtful engagement in life, work, and citizenship to create a more just world. Grassroots social issues and local community concerns are connected to global issues that have large-scale impacts. Ecology with cities is a relatively new term, emphasizing the holistic view of trans-disciplinary, urban community ecology that includes teaching, outreach, and other forms of community engagement (Byrne, 2022). This type of environmental focus is coupled with the designing, planning, and execution of laws and regulations that stress government participation and builds trust between underrepresented and impoverished families with their schools and communities, and prepares students for civic life by teaching the truth about the world around them (Goodman, 2022).

1.2 Explore the Importance of the Problem

Of foremost importance is the need to educate about environmental restoration, social justice and community responsibility. To accomplish this goal, students must first become aware of the issues and the impact of environmental restoration caused by human impact – both positive and negative. There is an urgent necessity for students to pursue education and employment in environmental restoration and preservation for the health and well-being of the planet as well as all of the abiotic and biotic inhabitants. Added to this is the issue of environmental social justice, ensuring the equal and fair treatment of all people, regardless of culture or ethnicity. By combining governance with citizen science, a synergy is created which transcends the dictation of laws and creates unity in community efforts for change and reform movements such as the urban environmental restoration crusade. Outreach to historically underserved communities is one of several methods that New York City is taking to reverse prior injustice (See figure 1).

Figure 1. A Public Service Announcement Located in a Low-income Community of Color

The topic of dwindling sustainable resources has been the subject of concerns for decades. Citizen education has been a part of the democratic fabric of this country since its inception. Citizenship and community engagement are fundamental for the next generation to promote democracy, human rights, and social justice. The participatory process of reflection and action, needed both individually and collectively is the practice of citizenship. As a result of increasing globalization and technological development, it is essential that students develop skills for integrating emerging knowledge and solving complex problems (Santos, Carlos & Moreira, 2023). To achieve full participation in science and the associated policymaking, students must engage in data gathering activities, community-based environmental monitoring, data collection and interpretation, and providing answers. This is known as citizen science. Although participatory science is increasingly being added to the secondary school curricula, studies have shown that there is a need for this type of community-based environmental involvement beginning earlier in a student's academics. Children in early childhood are naturally curious about their environment, and learn primarily through direct experiences and through their senses (Fortino, Gerretson, Button & Masters, 2014). These tactile experiences help younger students to appreciate plants and animals, as well as providing enhanced literacy and math skills.

Participatory environmental science, which encompasses a vast number of academic fields (mathematics, science, engineering, information technology, sociology, law, social science, environmental respect and stewardship) is crucial, not only for the individual student but for society as a whole. Embedding pedagogies that comprise citizenship and engagement in community issues promotes students' involvement at school and in the community and influences local environmental policies. Arming future generations with the knowledge and critical thinking skills to rectify human impact on the environment will certainly improve conditions in the near future and hopefully create a sustainable impact. The importance of local perspectives and the negotiation of competing interests in environmental causes can be taught by engaging students in the process of social and ecological collaborations in urban areas. Essentially, providing the next generation of environmental researchers and practitioners with foundational experience for how to navigate such partnerships in their own careers can be attained by focusing on the process of collaboration (Toomey, Smith, Becker & Palta, 2023). In a similar study, students' prior lack of citizenship and engagement in community issues was addressed through pedagogies that helped to develop student autonomy, responsibility, and citizenship by focusing on communal issues. Results indicated a greater student involvement at school and in the community.

The mission of the CCERS BOP project, in all of its iterations, is to combine systems thinking, community engagement activities and urban environmental restoration education to the New York City K-12 students. The focus of the project is the restoration of the Eastern oyster to the waters of New York Harbor. New York City is not unique in that it has the basis of its existence on the ecological bounty found within. Established as New Amsterdam in 1609, the area was already inhabited by indigenous people known as the Lanape. In fact, most of the area around what is now New York City was not inhabited but the abundance of wildlife and clean, fresh water made New York (New Amsterdam) a prime location for humans. One of its many attributes was the abundance of oysters found in the waterways that surround the island of Manhattan (Homberger, 2005). The arrival of Henry Hudson introduced Europeans to one of the world's most imposing natural harbors and a wealth of aquatic wildlife including whales, otters, turtles, and countless fish. Over 220,000 acres of oyster beds lay below the surface on the harbor floor, constituting nearly half of the oysters in the entire world (Hynes, 2022). Oysters played a critical role in the history of New York City. Throughout its early history, the city relied on the oyster as a food source and as a staple in its aquatic ecology. Oysters were served in the most exclusive restaurants, such as Delmonico's as well as in pushcarts by vendors along the streets of New York. The Eastern oyster (*Crassostrea virginica*) is a keystone species in the harbor and as such, provided a habitat for hundreds of other estuary species. However, after excessive pollution and overharvesting, the oyster population in New York Harbor was teetering on extinction. The last commercial oyster bed closed in 1927 and it was not until the Clean Water Act of 1972 that the harbor's water quality began to increase but the oyster population was slow to rebound (Kurlansky, 2006).

The Curriculum and Community Enterprise for the Restoration Science STEM + C Project (CCERS STEM + C) is a National Science Foundation (NSF) supported initiative designed to work with teachers and students in New York City public schools. Initially, the CCERS STEM + C Project focused on New York City public middle-school students and teachers with an emphasis on low-income, underrepresented minority students. Throughout its tenure, the project has expanded to all grade levels while staying true to its mission to underrepresented minority populations within the New York City school system. This article represents the results of a study conducted with a subset of secondary students (middle-school and high school students) who participated in the Billion Oyster Project (BOP) science activities. The BOP science activities were divided into two categories, those that included the CCERS STEM + C curriculum and those that did not. Over five hundred students participated in the BOP science activities and completed the research and evaluation surveys. The purpose of engaging the students in the CCERS STEM + C curriculum driven BOP science activities was to determine the efficacy of the activities to impact the awareness, motivation and engagement in community-based environmental restoration on the participating students, especially under-represented groups of students. Students who engaged with BOP science activities that included the CCERS STEM + C curriculum comprised the treatment group and students who engaged with the BOP science activities without the CCERS STEM + C curriculum comprised the comparison group. The two student groups were of comparable demographic composition. Measurements of scientific identity, STEM career interest and preparation to pursue STEM careers were chosen to determine awareness, motivation and engagement in community-based environmental restoration.

Students' values and expected success in a subject predict their achievement in the subject (Wigfield & Eccles, 2000). Disengagement in STEM is related to factors such as self-efficacy, prior achievement, perceived levels of difficulty, interest, gender stereotypes and career aspirations (Britner & Pajares, 2006). Beginning in early childhood and through adolescence, students' achievements in science and mathematics and the choices made stemming from these achievements, or lack thereof, create a STEM pathway. Achievement-related behaviors such as educational and career choice are precursors to expectations of success, and increased social and economic capital (Wang & Degol, 2013). Females often perceive STEM disciplines to be "male-oriented" and not equitable in acceptance or inclusion, leading them to disengage, particularly in STEM subject content (Archer et al., 2013). Engaging students in hands-on, informal learning environments helps to challenge the stereotypic views about STEM perceptions of difficulty and gender/ethnic bias (Roberts, et al., 2016). By creating relevance through community-based, social/environmental justice context, gender/ethnic underrepresents group understand the importance, applicability and purpose of STEM in their lives. Developing ways to improve interest in STEM subjects, so that students see the relevance and value of STEM in their lives, may improve STEM participation rates (Berger, Mackenzie& Holmes, 2020). During middle school and high school, students make critical educational choices in terms of STEM education (Maltese & Tai, 2011). These choices may exclude future educational and career pathways in STEM (Watt, 2006). In fact, much of the disparity in both gender and ethnic representation in STEM fields at university could be accounted for by differences in secondary school course-taking (Riegle-Crumb & King, 2010). An additional impact on STEM choices are motivational beliefs, which are heavily influenced by family, peers groups and gender/ethnic perceptions. These are strong predictors of activity choice, engagement, and performance (Durik, Vida & Eccles, 2006).

In a study that is similar to the CCERS STEM + C study in terms of environmental educational research (Perdrial et al., 2023), the impact of the team science approach can be seen in indicators which include the number of students trained in collaborative team science approaches, the community members engaged, and the strength of collaborative relationships established. Findings indicated that interdisciplinary pedagogical practices should include real-time data-gathered activities with subsequent classroom analysis and interpretation. The study's findings suggest that to build a bridge for participatory citizenship, teachers should engage students in communal environmental issues in a

STEM approach. With the help of the open source platform, computer science strategies fostered students' participatory citizenship. There was a huge involvement of the partners and municipality in the training sessions and in the educational community awareness activities, contributing to a greater articulation between the school, higher education and community businesses. There is a decisive shift from the activism of specific sites of the 1980s-1990s to the current community planning and community-based research by community members and environmental activists working locally to solve global issues and fuel environmental justice activism (Sze, 2006).

1.3 Hypothesis

The hypothesis of this study is to determine if participation in the BOP CCERS STEM + C Project increases student awareness, motivation and engagement in community-based environmental restoration. Additionally, the study determined is there is an increase in awareness, motivation and engagement in community-based environmental restoration in under-represented groups of students Underrepresented groups were identified as those who self-identified as one of the following: a woman, person with disabilities, or as an underrepresented minority (Black, Hispanic, and American Indian or Alaska Native).

2. Method

A student survey instrument which contains the i) motivation to pursue STEM careers subscale, ii) preparation for STEM careers subscale, and iii) engagement with scientists. Using an existing survey, instrument refinement was conducted to increase the response rate by reducing participant burden and length of time required to complete all necessary survey steps. Data collected from previous phases of the project were used to conduct item reduction analysis. The primary goal of this analysis was to obtain functional items (i.e., items that are correlated with each other, discriminate between individual cases, underscore single or multidimensional domain, and contribute significantly to the construct). The researchers determined the effect of deleting a given item or set of items by examining the item information and standard error function for the item pool. Further, the refined instrument was evaluated by key project personnel for content relevance, representativeness, and technical quality.

2.1 Measuring Key Constructs

Two key constructs were the foci of this research: motivation and preparation to pursue STEM careers. In order to measure motivation to pursue STEM careers, researchers used the following:

a. Scientific identity was used due to its effectiveness in predicting persistence in STEM careers for K-12 students. Scientific identity can be broadly defined as the aspects of the self that relate to science. Individuals who highly identify with science are more likely to make decisions that validate that identity and may be better able to maintain their motivation to persist in STEM fields. Respondents answered four questions on a Likert scale with ratings from 1=strongly disagree to 5=strongly agree regarding their scientific identity. Cronbach's alpha was run to examine internal validity, resulting in a score of.80, indicating there are good levels of internal validity in the scientific identity subscale. Items were averaged to compute an index, with higher average scores representing higher scientific identity.

b. Students' STEM career interest was used due to a plethora of research that identifies STEM career interest as a strong predictor of motivation and persistence to pursue STEM careers. Respondents answered two questions on a Likert scale with ratings from 1=strongly disagree to 5=strongly agree regarding their interest in pursuing careers related to STEM. Items were averaged to compute an index of career interest.

c. Preparation to pursue STEM careers was measured using engagement as a proxy variable. Engagement was chosen as a proxy because research has long demonstrated the strong relationship between students' self-reported preparation to pursue STEM careers and their reported level of scientific engagement. Thus, researchers measured two types of engagement:

i. General engagement with a scientist – Respondents answered one question on a Likert scale with ratings from 1 = not at all engaged with a scientist to 5= extremely engaged with scientist regarding their general engagement with a scientist.

ii. Engagement in specific scientific activities – Respondents answered five yes or no questions on whether they had participated in a variety of scientific activities in the past 12 months (e.g., attended scientist talks, read scientific articles, listened to a scientific podcast). Additionally, "yes" was coded as 1, and "no" was coded as 2 for this variable's responses, with higher scores meaning fewer engagement behaviors. For analysis purposes, this variable was reverse coded to make higher scores reflective of higher levels of engagement behaviors.

2.2 Participants

Five hundred thirteen middle and high school students were sampled. Each obtained parental consent (if 17 years of age or younger) and assented to complete the survey. Students participated in the research study through general outreach efforts of the BOP team. Students at local New York middle and high schools were invited to participate in BOP science activities. Some of those activities included CCERS curriculum and others did not. Assignment into CCERS (treatment group) and comparison groups was made on the determination of the presence or absence of CCERS curriculum in BOP activities. Any student who participated in at least one BOP event that included the CCERS curriculum was considered part of the CCERS (treatment) group. Those who participated in activities that did not include the CCERS curriculum were assigned to the comparison group. Project staff recruited student groups of comparable type and demographic representation to comprise CCERS and comparison groups. Researchers used information received from BOP and PI to identify which students attended specific events.

The research team, PI, and BOP staff recognized after six months that participation in both the treatment and comparison groups was below expected recruitment numbers, thus, collaborated to refine the sampling strategy. Using information gathered from previous phases and literature on school-based interventions (Krajcik, Blumenfeld, Marx, & Soloway, 1994), the project staff identified various additional strategies to increase sample size (e.g., holding community events, holding information sessions for parents, increasing project outreach personnel). In addition, project staff used a mix of purposeful and snowball sampling techniques and used multiple forms of advertisement (e.g., project website, project social media page, flyers). Furthermore, key project personnel scheduled monthly meetings to discuss ways to continuously refine and improve recruitment strategies throughout the length of the project.

This report includes responses from participants who provided both student assent and parental consent per the IRB requirements. A total of 513 students with parental consent and student assent completed the research and evaluation surveys. Figure 2 displays the respondent demographics in further detail.

Table 1. Demographics Table by Participation Condition and Overall

Demographics	Comparison Group (N=90)	CCERS Group (N=423)	Total (N=513)
Gender			
Male	40 (44.4%)	113 (26.7%)	153 (29.8%)
Female	24 (26.7%)	125 (29.6%)	149 (29.2%)
Do not wish to specify	—	24 (5.7%)	24 (4.7%)
No response	26 (28.9%)	161 (28.1%)	187 (36.4%)
Ethnicity/Race	—		
Amrican Indian or Alaska Native	3 (3.3%)	5 (1.2%)	8 (1.6%)
Asian	7 (7.8%)	37 (8.8%)	44 (8.6%)
Black or African American	10 (11.1%)	32 (7.65)	42 (8.2%)
Hispanic/Latino	15 (16.7%)	74 (17.5%)	89 (17.3%)
White (non-Hispanic or Latino)	26 (28.9%)	75 (17.7%)	101 (19.7%)
Other	3 (3.3%)	13 (3.1%)	16 (3.3%)
Do not wish to specify	—	30 (7.1%)	30 (5.8%)
No response	26 (28.9%)	157 (37.1%)	183 (35.6%)

2.3 Data Analysis

Researchers examined the data for patterns of omissions, normality of distribution and multicollinearity. For data that met all the assumptions, an independent samples t-test was used to examine if there were statistically significant differences in the measured outcome variables between the CCERS (treatment) and comparison groups. For continuous data that did not meet the assumptions of equality of variance, Welch's t-test was used, and for categorical data, Fisher's exact test was used. The research team presented the means and standard deviations of the indices for each of the groups identified.

Between 32% and 45% of data were missing from the variables of interest (access to technology, career interest, engagement in STEM, school use of technology, technological abilities, self-efficacy) above the typically acceptable 10%. It was decided that, rather than conducting a itemize deletion in the entire dataset (i.e., delete any participant who had missing data), which would have reduced the number of participants from 513 to just 11, missing data were removed as models were created, only removing missing data from the variables in each model.

Because it was suspected that the data would not be normally distributed, an assessment for the normality of the data was done before outliers were identified. Skewness and kurtosis were within the normal range (-2 < skew < 2, -7 < kurtosis < 7) for all variables. Despite this, none of the histograms appeared to be normally distributed. This was confirmed by a Shapiro-Wilk normality test, which showed that none of the variables used in the analysis were normally distributed. Because of this, non-parametric tests were deemed more appropriate to use than parametric tests for analysis. As a result, outliers and homoscedasticity were not tested for. Specifically, outliers were not removed because the large amount of missing data means further removing data could severely under power the results of any analysis. Simple correlations between the variables were assessed to examine whether any variables may increase the risk of high inter-correlation. A correlation matrix revealed that no variable had a Pearson's r with an absolute value greater than 0.8, meaning no individual variable posed a risk to multicollinearity.

3. Results

3.1 Findings

A total of 764 students opened the survey through the general link and arrived at the landing page in Step 1.

A total of 513 respondents completed all the necessary steps for the surveys (i.e., steps 2 & 3), including providing parental consent and student assent. Data were collected between September2019 through December 2022.

- CCERS respondents, on average, had higher scores on scientific identity (motivation) and higher levels of preparation, with higher average scores of general engagement than the comparison group. A model was created to test the relationship between condition (i.e., treatment and comparison) and scientific identity. Though non-significant, on average, CCERS respondents (n=281) expressed a slightly higher scientific identity (M=3.85, SD =0.78), than comparison group respondents (n= 80, M=3.69, SD=0.72).

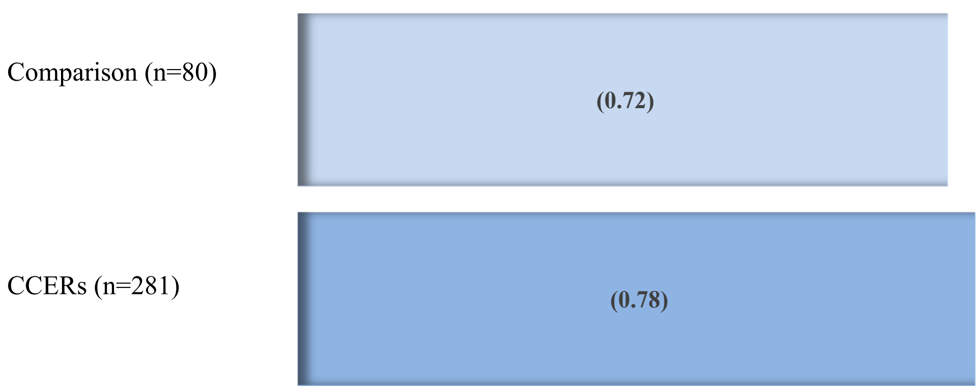

Table 2. Average Scientific Identity of Respondents from the CCERS and Comparison Groups

- Underrepresented group (URG) CCERS respondents, on average, reported higher levels of scientific identity (motivation) and engagement in scientific activities (preparation) compared to URG students who did not participate in CCERS. On average, though non-significant, URG CCERS respondents (n= 84) expressed a higher sense of scientific identity (M=3.87, SD=0.71), than the URG comparison group respondents (n=21, M=3.64, SD=0.65).

Table 3. Average Scientific Identity of Respondents from the URG CCERS and URG Comparison Group

4. Discussion

The BOP CCERS in New York Harbor project aims to meaningfully connect STEM teaching and learning to the environmental restoration of New York Harbor to create enhanced STEM education and STEM career outcomes for students historically underrepresented in STEM fields. Building confidence in the application of science related skills (e.g., data collection, scientific inquiry, data analysis), makes data science more accessible to students as they consider their academic and career paths. The goal of CCERS is to create opportunities for students to develop their technological abilities, engage in STEM, identify as scientists, and increase their career interest. Research findings provide support for the CCERS Model. Significantly higher reported levels of engagement in STEM activities for students in the treatment condition compared to students in the comparison condition are found. Additionally, findings indicate that participation in CCERS activities may have varying levels of impact across different groups (e.g., different grades, gender). Specifically, 11th grade students in the treatment condition were able to see themselves as scientists more than students in other grades. In addition, when examining career interest, a key predictor for STEM motivation and interest, we saw a similar pattern for 9th grade females, in which 9th grade females in the treatment condition reported higher levels of career interest than females in any other grade. It may be that novelty drew this particular subset of students to the idea of a STEM related careers, as novelty is a possible need that fuels intrinsic motivation (González-Cutre, Sicilia, Rodriguez, Ferriz, & Hagger, 2016). Lastly, with regard to engagement in STEM, which is a behavioral measure of students doing things like reading scholarly articles, listening to science podcasts, and community based volunteering, students in the treatment condition scored higher than students in the comparison condition. These results partially generalized to students who identified with an underrepresented minority.

The results demonstrate that certain groups benefit more than others and serve as groups of interest to explore in the next iteration of the project. A focus on understanding what explains the differences we see with students in 11th grade or female students in 9th grade may prove most impactful. Future project implementation could investigate what drives the increased STEM career interest and motivation for these groups in particular to see if the greatest impacts can be sustained throughout the project. Moreover, future longitudinal studies should measure the duration of such changes and determine what supports may be necessary to sustain these levels.

In general, people develop goals to pursue academic and career activities that are consistent with their interests as well as with their self-efficacy and outcome expectations (Lent, Ireland, Penn, Morris & Sappington, 2017). When people are interested in something, they become more attentive and alert; in fact, playful engagement with science during childhood and youth influences interest in science during adolescence (Archer et al., 2010). The data suggest several opportunities for the CCERS program. Greater efforts can be made to increase access to mentorship from scientists and to connect students with volunteer opportunities, both of which can further increase interest and engagement in STEM. Career interest is associated with an increase in awareness of STEM careers, which is associated with an increase in STEM engagement; therefore, increasing access to mentorship and volunteer opportunities is a concrete intervention school can implement that may directly benefit students. The development of more diverse, inclusive, and equitable geoscience pathways will lead to culturally relevant research agendas, deepened disciplinary knowledge and skills, as well as the ability to develop interdisciplinary science teams to solve problems (Honey, Schweingruber, Brenner, & Gonring, 2021).

Future research is needed to unearth trends in environmental injustice and environmental quality. Education is the nexus between social and environmental equity in the communities that comprised New York City. Research coupling environmental restoration education, environmental justice, and sustainability will help to elucidate viable paths for achieving goals of both social equity and environmental sustainability. Methods of sustainable restoration of the harbor and innovative ideas are needed to illuminate and possibly resolve the problem. One of the highlights of the BOP CCERS + STEM C Project is the yearly Symposium held on Governors' Island. The symposium is held at the end of the school year and is a platform for students from across the city to share the work they have created and present to their teachers, peers, parents, citizen scientists, and researchers. Projects include topics such as scientific research, advocacy, and environmental justice that explore aspects of New York Harbor such as the ecosystems, built environment, human interaction, advocacy, environmental justice, community relations, and sustainable redesign. The BOP CCERS + STEM C students have worked alongside their teachers, researchers, and other citizen scientists and tackled some of the most important real-world environmental challenges that require resolution for a sustainable future. Students' passions can offer tremendous momentum for the advancement of important community-based learning, deepening their commitment to larger societal concerns (Russell & Jovanovic, 2023). An example of the student's creative work focusing on problem-solving for an equitable, sustainable future for New York Harbor is, "How can we propose a new design for CSOs (combined Sewer Overflows) to prevent sewage from going into our waters?" This independent research project is evidence that students who are involved in the BOP CCERS + STEM C Project are engaged in problem-solving and creative thinking skills beyond the norm.

The solutions to these problems are significant not only on the local community level but have extensive implications. Children need opportunities for collaborative decision-making from early childhood to exercise control of their environment – a core principle of democracy (Chawla & Cushing, 2007). Research has shown that this type of problem-based learning is significantly more effective than traditional instruction on students' performance in authentic situations and long-term knowledge retention (Yew & Goh, 2016). The STEM mission becomes synonymous with community restoration in the form of urban renewal and environmental restoration. Students develop science missions related to local societal issues that interest them in collaboration with their teachers and community experts, with frequent hands-on investigations outside the classroom and/or laboratory sessions (Montero & Leite, 2022).

Currently, more than 11,000 students to date in over 100 schools throughout NYC have participated in the BOP CCERS STEM + C Project. Through the work of some of these students, a bill was introduced (New York State Senate, 2021) – Assembly Bill A258/Senate Bill S4741. The proposal would establish a mollusk shell recycling tax credit for participating restaurants. Introduced in 2016, the bill went through the protocol of being presented to the committee and then placed on the floor calendar. Currently, the bill is awaiting (2022) approval at the assembly and senate level before being delivered to the governor of New York. https://www.nysenate.gov/legislation/bills/2021/a258.

In October 2012, Superstorm Sandy devastated much of the eastern seaboard of the United States but nowhere was the ferocity of the storm felt more than throughout the waterways of New York Harbor. Much of the shorelines of the five boroughs were submerged, with devastation ranging from the loss of housing, transportation, and lives. Arguably started in the aftermath of Superstorm Sandy, the climate justice movement exposed environmental racism that affects the housing and health of these underserved communities. Staten Island, the smallest of the five boroughs, was especially hard hit, with the loss of 57 lives, millions of dollars in property damages, and geographic changes to the landscape. In response to this inevitable outcome, restoration of the harbor began in earnest. In 2015, then Governor Cuomo launched a $60 million Living Breakwaters design for coastal resilience. Using state-of-the-art techniques, a series of in-water barriers seeded with oysters are placed along the south shore of Staten Island, providing new marine habitats that buffer the effects of storm surges and filter the pollutants from harbor waters.

In direct response, a Living Breakwaters curriculum has been developed to facilitate the awareness and education of the BOP CCERS STEM + C students. https://www.billionoysterproject.org/living-breakwaters-curriculum Systemic thinking, cause and effect and community and civic engagement and stewardship are emphasized in the curriculum. Students learn about the biodiversity of marine life in the Harbor and how creating a suitable and productive habitat is impacting marine organisms. A variety of organisms are using restored oyster reefs as a habitat in which to feed, reproduce, and take shelter. With the help of the New York Harbor species guide, the students ascertain the impact of the oyster restoration project through species regeneration. Oyster reefs provide habitat for hundreds of species, and can protect our city from storm damage — softening the blow of large waves, reducing flooding, and preventing erosion along the shorelines. The curriculum delves into the resurgence of the oyster population in New York Harbor and its vital importance in costal resilience. After the devastation of Superstorm Sandy to the New York Harbor and its surrounding land masses and waterways, reactive plans to fortify the waterways began. A viable, sustainable plan of action is the development of the Living Breakwaters. Positive human intervention is expected to reverse some of the destruction due centuries of negative human intervention. Aided by the oyster repopulation efforts, native aquatic organisms such as the American eel, isopod, sand shrimp, oyster toadfish, lined seahorse, and more have been repopulating the waterways (Brenner, 2021). Vegetation is also beginning to thrive which supports both the aquatic life as well as the avian wildlife. As of December 2022, more than 100 million oysters have been restored to New York Harbor with 16 acres (65,000m2) of reef area restored.

In November 2021, the Billion Oyster Project participated in the 2021 Conference of the NY-NJ Harbor & Estuary Program. As an outcome of the conference, a pledge was created to end systemic racism envisioning a future in which New York Harbor is the center of a diverse estuary that is universally accessible to all of the multicultural communities that constitute New York City. By creating safe spaces at the water's edge and expanding the presence of communities of color in decision-making, educational opportunities and employment, the Billion Oyster Project is taking a leading role in environmental justice and social action for all New Yorkers.

5. Conclusion and Implications

The BOP CCERS Model suggests that the partnership created by non-profit organizations, community based organizations, university partners, STEM industry leaders and the New York City Department of Education have established a replicable model that can be implemented in other parts of the country. Through these partnerships, collaborative research, environmental restoration focused initiatives and community based work; the model thrives at creating opportunities for underrepresented students in STEM related industries. The site specific initiative allows for student engagement, community volunteerism, scientific focused research and industry leaders to come together and work in unison to achieve those goals set forth in that particular community. The BOP CCERS Model has proven that these efforts are effective, useful, tangible and beneficial to all stakeholders as well as achieving the environmental restoration efforts set forth by the community based efforts. The project continues on modalities of expanding and creating a more diverse STEM workforce for future generations in order to support our ever changing and dynamic multiracial environments.

This study was conducted with the premise that instilling STEM identity in middle and high school students will increase STEM content knowledge, confidence in STEM engagement and an interest in STEM careers. Studies following the students' trajectories through post-secondary STEM course choices and STEM careers choices are encouraged. Elements of the CCERS STEM + C Project's curriculum should also be studies further to determine which factors contributed to the increased engagement and success of the students in the project.

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