The Curriculum and Community Environmental Restoration Science (STEM + Computer Science) Remote Learning Curriculum Use and Evaluation

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Abstract

The role of classroom teachers in the development of a well-designed curriculum is paramount. For this reason, teachers were asked to participate in the use and evaluation of a remote learning environmental restoration curriculum. The purpose of the study was to determine whether the participating teachers increased their content knowledge of STEM concepts and content related to the environmental restoration, specifically in terms of New York Harbor and oyster restoration, by participating in a remote learning curriculum pilot. New York City public school teachers of grades 6 through 12 instructed their students in the remote learning computer science curriculum lessons for one semester. A reflective survey was administered to the teachers at the conclusion of the semester and the findings indicated that 89% of the participating teachers experienced an increase in their knowledge of STEM concepts and content related to harbor and oyster restoration. The study was limited by the element of time and the model can be augmented in future iterations by increasing the length of the study to a full year of school and across several grade levels.

Keywords: digital literacy, environmental restoration science, educational inequality, remote learning curriculum, digital platform

1. Introduction

Inequity in education most assuredly did not begin in the 21st Century. Educators, parents and children have been grappling with the imbalance of resources, high-quality teachers and meaningful curriculum for centuries. As indicated in a study by Wright and Carrese (2002), findings indicate that high-quality teachers are enthusiastic, able to develop rapport with learners, committed to the growth of their students, and interested in learners as people. Students from low-income, minority communities attend schools with less qualified teachers than their counterparts in wealthier communities (Mangiante, 2011). In a study called Project Clarion (Kim, et al., 2011), results indicated that there was a positive achievement effect for low socio-economic students who were exposed to inquiry-based approach curriculum. High-quality curriculum is especially critical for low-income students and students of color whose schools often have low-quality learning materials (National Institute for Excellence in Teaching, 2021). Studies of educationally top-performing countries indicate that a shared characteristic is high-quality, content-rich curriculum (Steiner, 2018). Students in low-income communities continually experience deficits which impact the quality of education they receive and ultimately, the trajectory which will lead them from cradle to career. Studies have indicated that there has been a sharp increase in inequality in education since the onset of the pandemic which closed schools in the spring of 2020 (Haelermans, et al., 2022). Results indicate that the inequities in learning lose during the pandemic were directly correlated to parental education and income. In a study utilizing nationally representative datasets of cohorts born from 1908 through 1955, income inequality has progressively moved up the ranks of factors that predict educational inequality and is currently the primary factor in educational inequality (Jackson & Holzman, 2020).

Coupled with this growing dilemma is the fact that the natural environment is an area of education that needs the desperate attention of the next generation. The urgency of students to become stewards of the environment has never been greater. However, this cannot happen unless several factors are in place. Students, and especially students who have been marginalized due to gender or racial slights, often do not feel that they are welcome or capable in the areas of STEM education. This must change if these vital and capable voices feel a sense of agency when it comes to the natural environment. Descriptions of contributory citizen science projects emphasize four common characteristics: (a) members of the public are active participants; (b) following a specific citizen science protocol is critical to contributing to the value to science research; (c) professional scientists use citizen science data to generate knowledge about real-world problems; and (d) a virtual collaboration occurs where participants and scientists share data online (Bonney, Phillips, Enck, Shirk, & Trautmann, 2014).

The United Nations (United Nations General Assembly, 2019) recently declared 2021 – 2030 as the "Decade of Ecosystem Restoration". The resolution was adopted by the General Assembly on March 1, 2019. Coined as a global rallying cry to heal the planet, its mission is to prevent, halt and reverse the degradation of ecosystems on every continent and in every ocean. Ecological restoration has the potential to improve air quality, reverse forest clearance and desertification, slow biodiversity loss, enhance urban environments and perhaps improve human livelihoods and humanity's relationship within nature (Perring, et al., 2015). Environmental restoration is crucial for the welfare of the planet and humanity. In a study conducted by the Yale Program on Climate Change, four generations of Americans were examined on global warming beliefs and engagement. Findings on the *Climate Change in the American Mind* surveys indicate that younger Americans see global warming as a personally important and express a willingness to engage in environmental activism (Ballew, et al., 2019). In addition, in a recent article in Greenbiz, studies show that generation Z and millennial members are more concerned with global challenges. Having been born in the digital age, these generations are seen as being more socially aware and environmentally responsible (Hassim, 2021).

All indications are that an inclusive younger generation is poised to take up the gauntlet to continue the restoration work that has begun and to enhance and expand on these beginnings. Education is the critical component in giving these students a sense of empowerment and agency. The ultimate purpose of education is to empower learners to think, to feel and to ask. Experiential education in particular in particular can be a very effective means through which these and other skills can be developed (Shellman, 2014). Combined with their drive for environmental restoration is the fact that the current generation of students are digital natives, coming of age in tandem with the advancements of the growing force of technology. The recovery of nature aided by digital technology could steer humanity and the biosphere towards a better future. By utilizing the talents, skills and education of the younger generation, environmental restoration and redevelopment can become realities. It is time to act and empower them (Jepson, 2022).

Many studies have been conducted discussing the need for environmental restoration (Turner, et al., 2010), the use of digital technology in environmental education (Lai, Chang, Li, Fan, & Wu, 2013); (Janis, Birney & Newton, 2016) and the importance of teacher effectiveness in making students, especially those who feel disenfranchised, become actively engaged in STEM learning, advocates for environmental restoration and see themselves as agents of change and stewards of the environment (Sutradhar & Naraginti, 2022; Han, Kelley, & Knowles, 2021). Effective teachers generally use appropriate and varied educational resources in their preparation, articulate clear goals to the students with the expectation that their students can achieve (Cohen, Loeb, Miller, & Wyckoff, 2020). Previous research has concluded that teaching an integrated STEM curriculum that employs the application of several STEM skills and content engages students more than discrete subject content (Wang, Moore, Roehrig & Park, 2011). Students participate in real-world, project-based activities, embedded in environmental science and mathematics content framed by computer science applications. Since an integrated learning situation can complement and even enhance an existing curriculum, it is also favored by teachers (Yang, et al., 2021).

The curriculum is at the heart of these efforts. A well-designed, high-quality curriculum charts a course for student learning by setting in motion a sequence of experiences that build knowledge and skills and create strong critical thinkers. A high-quality curriculum and well-chosen instructional materials can also do the same for teachers (Short & Hirsh, 2020). During the past two years, Teachers had to shift much of their face-to-face pedagogy to that of the virtual world with varying measures of success. A sense of urgency for the reliance on computer science and digital technologies was felt by all members of the educational community. However, even before the pandemic, digital technology was increasingly utilized in education (Li & Lalani, 2020). The success of digital technology in education relies on its ability to be meaningful and interoperable for teachers and their students. The technology must give students, families and communities agency, not only with the technology but also with the content in the curriculum.

Some areas of education had already incorporated digital technology and computer science into their existing curriculum. For example, in 2015, the New York City Department of Education launched the Computer Science for All (CS4All), promising to provide all 1.1 Million New York City public school students – including those who are under-represented in technology-related higher education programs and careers – with meaningful, high-quality digital technology (NYCDOE, 2015). Promising to increase rigor and equity, a number of projects and programs became integral to the expansion and success of CS4All. A key project from the onset of CS4All is the Curriculum and Community Enterprise for Restoration Science in New York Harbor STEM + C Project (CCERS STEM + C).

The use of digital technologies to improve environmental education and activism can take several forms. In the Curriculum and Community Enterprise for Restoration Science in New York Harbor STEM + C Project, (CCERS STEM + C), digital technology is centered on the Billion Oyster Project Digital Platform that was established at the onset of the project in 2014. The function of the digital platform is to act as a dynamic repository for educational and restoration resources and materials. Capable of several and varied functions, the platform supports the following:

- Environmental Restoration Education Resources – Teachers, students, and administrators have access to the curriculum units of study and the STEM lab materials. Teachers can upload, download and create lesson plans and educational resources to be used by the NYC K-12 students. The lessons and units are dynamic and fluid and teachers are encouraged to teach the lessons and make edits and adjustments to augment the materials for all educators and their students.
- Oyster Restoration Station (ORS) Field Data – Students, teachers, community advocates and citizen scientists can collect and upload data as well as download and analyze data sets taken from around New York Harbor by other participating groups. These data sets create rich research opportunities for the students and have the ability to connect the individual efforts of school groups into the larger NYC Harbor community.
- Symposium – Each year a student symposium is held at the end of the school year. The symposium is open to all 6-12 student in the New York City public school system and includes projects focused on NYC harbor restoration in the areas of engineering, scientific research, environmental justice, advocacy. Students have the opportunity to showcase their particular areas of interest and concern through authentic research.
- Reports – This area of the platform focuses on the research and evaluation reports for the CCERS STEM + C Billion Oyster Project. It is here that the development of the project, its current findings and its projected implementation can be found.
- Events – To meaningfully engage schools, restaurants, corporations, nonprofits and individuals to the waterways of New York City, the project hosted a series of events throughout the year. By connecting the community in this ongoing basis, the restoration-based education program benefits from the diverse backgrounds of its supporters.

The digital platform is an open-source arena allowing for all members of the community to use the resources as they are needed. High quality curriculum that is available as an open educational resource levels the playing field by offering free resources. Resource-based learning creates a better platform to transform a culture of open learning and teaching across many educational systems to offer a better quality to the significant number of learners (Sandanayake, T.C. (2019). This collaborative approach not only allows for more diversified ideas and innovations but contribute to the social justice ideal of STEM education for all. Flagg (2016) found the strongest learning outcomes for minority students who engage with digital learning tools. The project's use of a STEM focused "restoration through education" digital platform supports the activities of teachers and students in placed-based learning in educational data science. Digital platforms provide a context for motivational student-driven problem or project-based learning approaches, facilitating citizen science projects through learning participation and agency and real-world benefits (Cooper, 2016). Community restoration projects envision local people as the solution to habitat degradation and involve them at all stages of project development. These projects appear to perform better than large-scale integrated conservation and development projects (Horwich & Lyon, 2007).

An addition to the digital platform is the newly developed BOP CCERS (STEM + Computer Science) remote learning computer science curriculum. From January through June 2021New York City public school teachers participated in a program to pilot BOP CCERS (STEM + Computer Science) remote learning computer science curriculum with their students. Piloting is an important tool that increases the validity and reliability of the research. It helps to focus and adapt the research to the local situation (Gudmunddsdottir, & Brock-Utne, 2010). The CCERS (STEM + Computer Science) remote learning computer science curriculum consisted of several problem-based learning lessons that include topic, overview, driving questions, and supplemental resources. Teachers met monthly to discuss lessons and activities and to provide feedback on the curriculum. By sharing their experiences with the curriculum and students, the curriculum was used as a guide that helped to bring the students' experiences with the environmental remote learning computer science curriculum to the forefront. Teachers and students are currently experiencing many challenges as they adapt to remote learning instructional platforms. Their successful adaptation is essential. The process of sharing experiences facilitated teachers to come together as a community (Green, Burrow & Carvalho, 2020). At the end of their pilot program participation, teachers took a survey reflecting on their experience in the workshop sessions and in using the curriculum with students.

The primary hypothesis of this study is that after participation in the BOP CCERS (STEM + Computer Science) remote learning computer science curriculum pilot program, teachers will have increased their knowledge of STEM concepts and content related to oyster and harbor restoration. The secondary objective of the study is that after participation in the BOP CCERS (STEM + Computer Science) remote learning computer science curriculum pilot, the teachers will believe that the curriculum engages students and promotes interest in oyster restoration and research. In addition, the teachers will feel that the BOP CCERS (STEM + Computer Science) remote learning computer science curriculum facilitates high quality instructional practices.

2. Method

The study was conducted during a six month trial period with participants piloting the environmental science remote learning curriculum. Participants were recruited as a sub-set of participating teachers in the CCERS (STEM + Computer Science) project. The study was designed to investigate the efficacy of the remote learning curriculum, specifically for increasing participants' content and skills in the environmental restoration science project. The participating teachers were asked to complete the Curriculum Pilot Program Participant Survey to detect to what extent the remote curriculum transformed teachers' perceptions in their own environmental restoration content knowledge and skills and their perceptions of this effect on the students STEM careers awareness. Surveys that are similar in nature have been applied in educational research (Caruana, Woodrow & Pérez, 2010). Evaluation was based on the participating teachers' perception of the value of the environmental restoration science (STEM + Computer Science) remote learning curriculum in providing opportunities for participants to increase their skills and content and raise student awareness of oyster restoration research and STEM career opportunities.

2.1 Participants

New York City public school teachers of grades 6 through 12 were selected to participate in the CCERS STEM + Computer Science Remote Learning Curriculum Pilot. Teachers shared the remote learning computer science curriculum lessons with their students from January 2021 through June 2021 (one semester). Monthly meetings (workshops) were conducted with the teachers and the external evaluator to discuss the lessons and activities and to provide feedback on the curriculum and its intended impact. At the conclusion of the pilot, the teachers were given a survey asking them to reflect on their experience in the workshop sessions and in using the curriculum with their students.

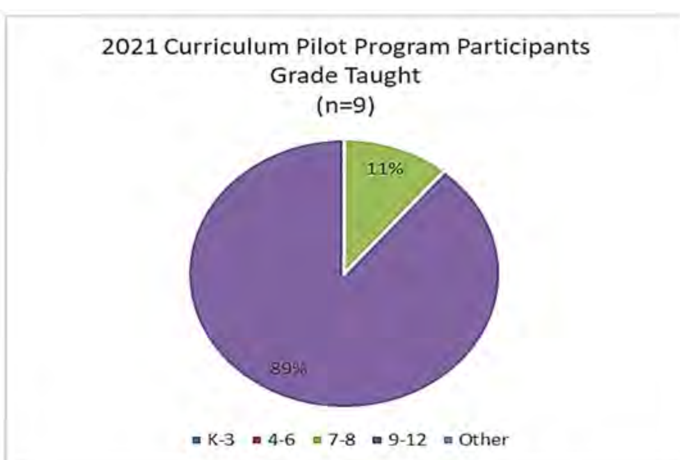

Figure 1. Curriculum Pilot Participants

Thirteen New York City public school teachers were selected to participate in the pilot program with nine of the participants completing the survey (As referenced in Figure 1). 89% of the respondents are high school teachers (Grades 9-12) and 11% are middle school teachers (Grades 6-8). Approximately 440 students participated in lessons from the pilot remote learning computer science curriculum program.

2.2 Research Design

This is a qualitative study with results based on a reflective survey given to the teachers at the conclusion of the pilot program. The survey consisted of two types of questions. One consisted of questions followed by statements from which the teachers could choose. The second was composed of statements followed by a Likert Scale from 1 (Strongly Disagree) to 6 (Strongly Agree). A data analysis was used to codify the responses and communicate the results. The Likert-type items were combined into a composite score/variable in the data analysis process. The survey focused on selections based on the teachers':

1. Reasons for participating in the remote learning computer science curriculum pilot.
2. Teachers' perceived gains from participating in the pilot program.
3. Teachers' perceptions of the CCERS STEM + C Remote Learning Computer Science curriculum.
4. Teachers' perceptions of their students' interest in pursuing a STEM marine career after being taught with the CCERS STEM + C Remote Learning Computer Science curriculum.

3. Results

Teachers were asked why they participated in the curriculum pilot program (as referenced in Figure 2). Teachers could choose multiple responses to this question.

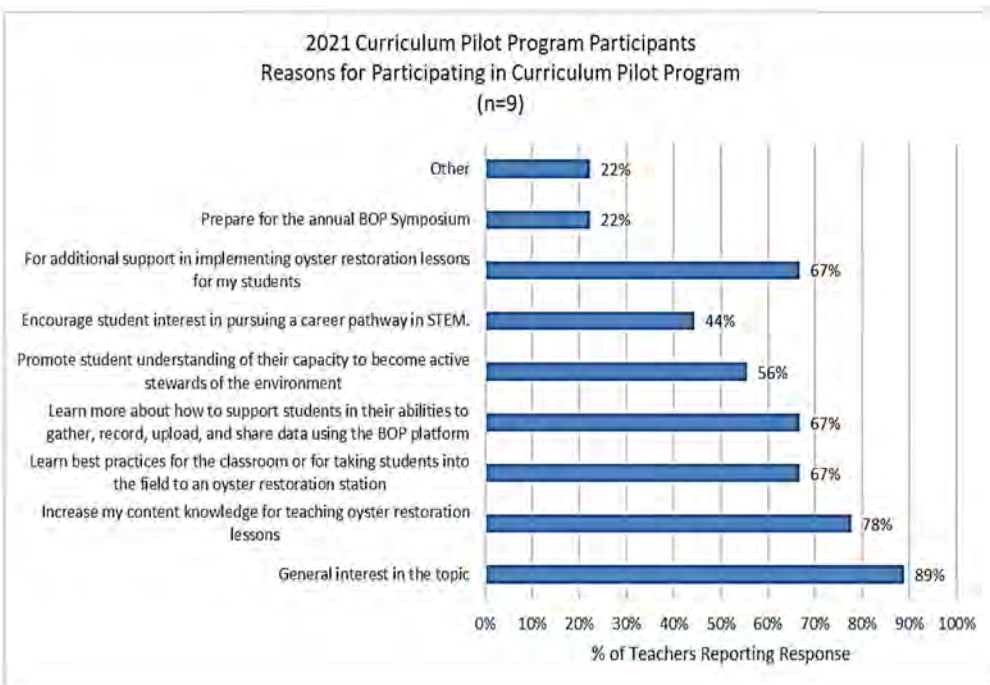

Figure 2. Reasons for Participating in the Pilot Program

The most frequent reason teachers cited for program participation was general interest in the topic, with 89 percent of respondents. An increase my content knowledge for teaching oyster restoration lessons was also frequently cited, with 78 percent of respondents.

Teachers responded to a series of statements about what they gained from their participation in the pilot program. Each statement was evaluated on a scale from 1 (Strongly Disagree) to 6 (Strongly Agree), the results of which can be seen in Figure 3).

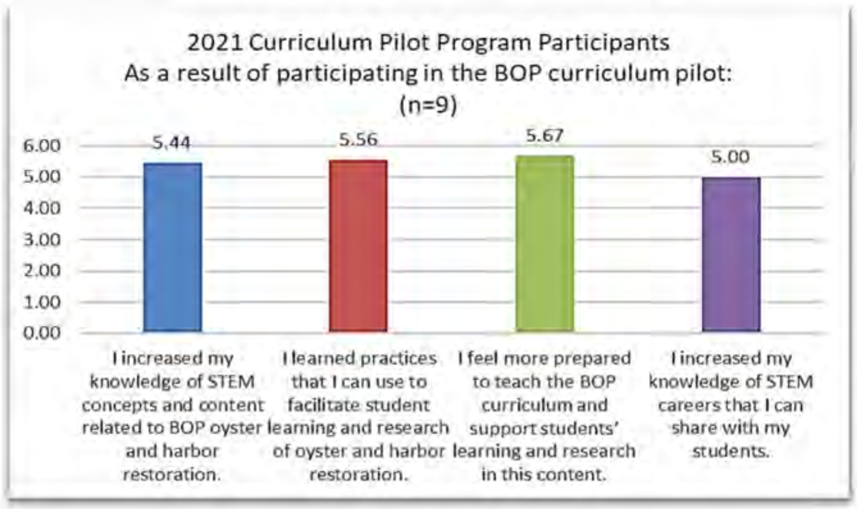

Figure 3. Level of Agreement with Participation Statements

Teachers' responses to all statements were positive with all average responses between 5.00 (Agree) and 6.00 (Strongly Agree). The highest average response was to the statement, I feel more prepared to teach the BOP CCERS (STEM + Computer Science) curriculum and support students' learning and research in this content with an average of 5.67 (standard deviation=0.71). The lowest average response was to the statement, I increased my knowledge of STEM careers that I can share with my students with an average of 5.00 (standard deviation=0.71). The low value of the standard deviation indicates that the responses were clustered closer to the mean value. The consistency of the responses indicates the reliability of the treatment.

Teachers also provided feedback on the sessions in which they met monthly with colleagues and BOP CCERS (STEM + Computer Science) staff to discuss the curriculum and engage in some of the activities. Teachers particularly liked being able to discuss different parts of the lessons with other teachers and having access to "real" data. Specific feedback on helpful aspects of the program included:

- Having real data that was collected by students and community members.
- I really appreciated hearing how other teachers modified the curriculum for students with disabilities. I also liked meeting before the Symposium to get feedback on my students' work.
- Reviewing the curriculum and sharing our work - it forced a deep dive into the lessons.
- Getting kids using Google sheets for data analysis because it helped them navigate data sets and figure out ways of analyze and graphically representing trends they found in the data. This feel more like "real science" compared to more cookbook lab type curricula.

More specific questions can be seen in Figure 4. Teachers responded to questions that focused on the piloted curriculum in more depth.

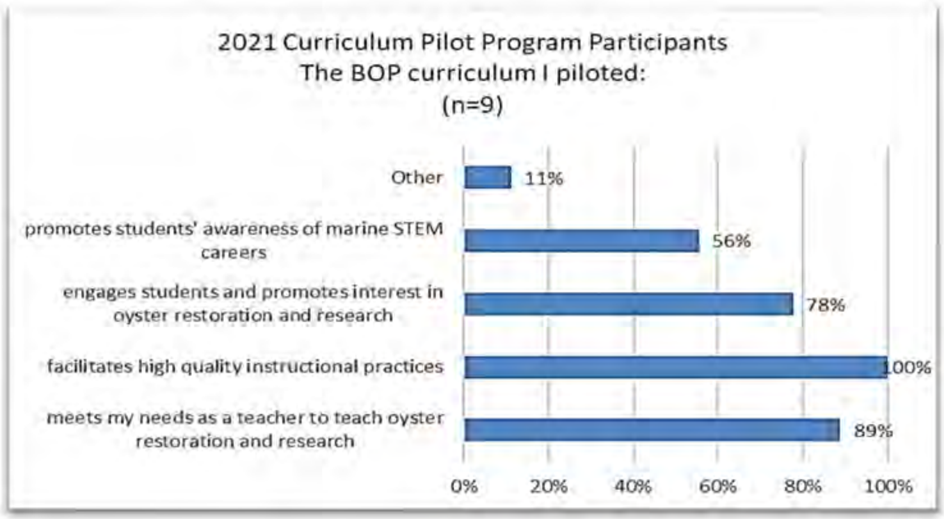

Figure 4. Answers to Questions Concerning the Curriculum

All of the respondents thought that the BOP CCERS (STEM + Computer Science) curriculum facilitates high quality instructional practices. Eighty-nine percent said the curriculum meets teachers' needs for instruction to teach oyster restoration and research. Promoting students' awareness of marine STEM careers received the lowest percentage in terms of response was lowest response with 56 percent responding. An additional response stated that the environmental science pilot curriculum required a lot of custom modification based on the time and space due to the fact that the teacher could not teach the entire lesson sequences in their original form.

Teachers rated the BOP CCERS (STEM + Computer Science) curriculum lessons on a scale of 1 (Useless) to 5 (Excellent).

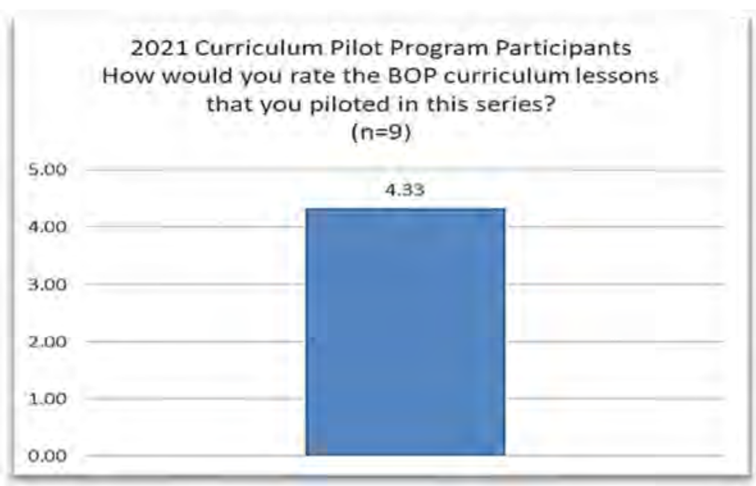

Figure 5. Ratings on Piloted BOP CCERS (STEM + Computer Science) Curriculum Lessons

As indicated in Figure 5, the average rating of the lessons in the curriculum pilot was 4.33 (standard deviation=0.50). This falls between 4 (Good) and 5 (Excellent).

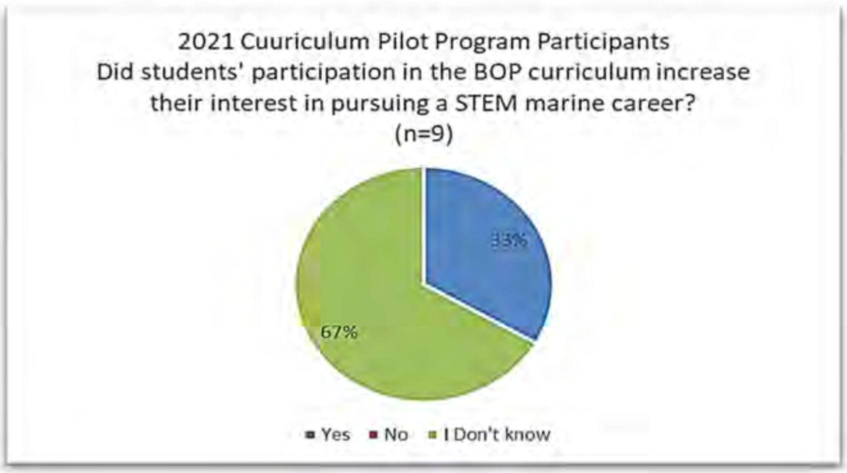

Figure 6. Student Interest in STEM Marine Career

When asked if students' participation in the lessons increase their interest in STEM careers, (See Figure 6), 33 percent of respondents said yes. Sixty-seven percent did not know if participation increased student interest in STEM careers. This response is in line with other responses from teachers related to STEM careers. Teachers reported less interest in career content and less awareness of student interest overall.

4. Discussion

The focus of this study was to determine whether teachers have increased their knowledge of STEM concepts and content related to BOP CCERS (STEM + Computer Science) oyster and harbor restoration after participation in the remote learning computer science curriculum pilot program. The response to the statement, I increased my knowledge of STEM concepts and content related to BOP CCERS (STEM + Computer Science) oyster and harbor restoration, averaged 5.44 (standard deviation=0.71). The relatively low value of the standard deviation indicates a clustering of the responses closer to the mean.

The secondary objective of the study was related to post-participation in the BOP CCERS (STEM + Computer Science) remote learning computer science curriculum pilot. The teachers believe that the curriculum engages students and promotes interest in oyster restoration and research at the conclusion of the pilot. 78% of the participants responded that the remote learning computer science curriculum does engages their students and that the students have a greater interest in oyster restoration and research after their experience with the BOP CCERS (STEM + Computer Science) remote learning computer science lessons. The results of this study indicate that both the primary and secondary objectives of the study were successful. The majority of the participating teachers in the study conveyed that their knowledge of STEM concepts and content related to BOP CCERS (STEM + Computer Science) oyster and harbor restoration increased after their participation in the remote computer science curriculum pilot program. Additionally, 100% of the participating teachers feel that the remote computer science curriculum engages students and promotes interest in oyster restoration and research and that the remote computer science curriculum facilitates high quality instructional practices.

Overall, participants rated the remote learning curriculum and associated workshops highly and had a positive experience in the program. Areas for possible improvement that were cited by the participants were (1) making the curriculum more flexible to meet a range of needs for teachers and (2) placing greater emphasis on STEM marine careers. Even with these areas of improvement, teachers' perceptions of the program and curriculum support this being a high-quality program.

To develop critical thinking and communication skills as well as allocate rigorous content, an exceptional curriculum is needed. The key positioning of the school curriculum should be to enhance children's capacity to utilize their agency, both with respect to their own life courses and within a society. A focus on agency is crucial for personal empowerment and for the wider social, political and economic outcomes. (Manyukhina & Wyse, 2019). To advance large scale educational equity, a curriculum must be widely circulated, especially to schools in communities that are marginalized. Professional learning opportunities in the curriculum must also be strengthened to ensure that students feel a sense of agency and acceptance of the materials. Embedded in the BOP (STEM + Computer Science) remote learning computer science curriculum is the universality of the environmental restoration content and the inclusiveness of the free access digital resources. Greenhow and Lewin (2016) speak of "participatory digital cultures" in regard to a sense of student agency and hope of affecting a positive impact on environmental sustainability. The environmental restoration computer science remote learning curriculum provides a greater opportunity for teachers and students to participate in real-world engagement, the practice of self-direction, advancement of science and engineering skills, critical research, extensive collaboration, and beneficial communication.

In a recent online panel discussion entitled, The Role of Media & Technology in the Future of Education (WNET Events, April 28, 2022), https://wnet.zoom.us/j/85090182035, many of the distinguished panel members expressed equanimity during all of the current educational uncertainties all students and teachers are experiencing. For example, a panel member stated that the current digital divide that disproportionately adversely affects African-American and Hispanic students, found that parents have a greater level of comfort with their children's teachers (though zoom lessons) and feel that the boundaries between the school and parents were bridged. Another felt that though the use of a more meaningful and dynamic digital curriculum, agency is given to students, parents and teachers. A third panel member stated that education has changed forever because of the positive aspects of technology and the involvement of community-based partners in providing free access to educational resources. Finally, a fourth stated that the increase dependence of digital technology has helped to bring communities together, showing students' that they are part of one large educational and societal community.

It is incumbent on future researchers to look at pedagogy, with technology as the tool to deliver instruction. Technology needs to be the bridge to an effective, progressive curriculum (Coker, 2020). Digital technologies emphasize learner engagement and connection to the hands-on, real-world activities. Digital technologies can support student inquiry through pedagogical approaches such as project-based learning. Remote learning enables communication amongst students at any number of schools, with experts in the field and community members (Buchanan, Pressick-Kilborn & Maher, 2019). As the fields of data-intensive environmental research and education continue to intersect, employment in data science for underrepresented populations is conceivable, such that the field can become both more gender balanced and representative of society at large in terms of ethnicity and other demographics (Hampton, et al., 2017).

5. Conclusion

The global pandemic that began in 2020 has inadvertently ushered in a prodigious development in the pedagogical world. Remote learning enabled students to continue with their education at a time when in-person learning was not an option. By ameliorating the educational dilemma, remote learning allowed educators to see the benefits of virtual education. Snow days, sickness, and even pandemics would no longer be an obstruction to learning. Currently, school districts across the country are developing remote learning options at an astounding rate. An analysis of the nation's 20 largest school districts (Belsha & Barnum, 2022) found that almost all of them will offer remote classes this fall — and at least half are offering more full-time virtual options than offered pre-pandemic. Some of the cities included in the study were Los Angeles, Chicago, New York, Dallas, San Diego, and Philadelphia. The New York City Department of Education (NYCDOE, 2022) has already announced plans to launch two virtual schools in the fall, which is seen as a necessary improvement to the existing infrastructure. Dubbed, "A School without Walls", one school will have a significant career and internship focus and the other will be completely remote (McDonough, 2022). The Curriculum and Community Environmental Restoration Science (STEM + Computer Science) Remote Learning Curriculum lends itself to the school favoring the career and internship focus. Being ahead of its time, it has already been vetted in several schools and because of innovative foresight, the curriculum spans several grade levels and meets the standards that have been set for science, mathematics, and computer science. As educators strive toward creating a more inclusive and holistic learning environment for students, it is critical to open the space for exploring alternative learning models (Rizvi, 2021). It is suggested that the use and evaluation of the Curriculum and Community Environmental Restoration Science (STEM + Computer Science) Remote Learning Curriculum be used as a model for future remote curriculum development and evaluation. Given its environmental restoration theme, its long-term project-based components, and its attention to underrepresented populations, life-long learning, and career explorations, it can easily be adapted to suit the needs of other large school districts with challenges that mirror those in New York City.

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