The Curriculum and Community Environmental Restoration Science (STEM + Computer Science) Project – Attaining a STEM Mindset Through Improved Technological Ability

Lauren Birney[1,*] & Denise M. McNamara[2]

[1]Pace University, USA

[2]The College of Staten Island, USA

*Correspondence: School of Education, Pace University, USA. Tel: 1-212-346-1889x11889. E-mail: lbirney@pace.edu

Received: September 1, 2023 Accepted: December 5, 2023 Online Published: February 15, 2024

doi:10.5430/jct.v13n1p394 URL: https://doi.org/10.5430/jct.v13n1p394

Abstract

Increasing students' confidence in their technological ability has been found to have a broader impact on their content knowledge in several subject areas, but most strikingly, in STEM (science, technology, engineering, and mathematics). A sample of 513 students in grades 6 through 12 in the New York City public school system were questioned on their perceived technological ability after participating in The Curriculum and Community Environmental Restoration Science (STEM + Computer Science) Project, hereafter referred to as the CCERS STEM + C Project. Also explored was the students' access to technology to determine if this would be a factor in student self-efficacy in technology ability. Analysis revealed that science self-efficacy and technology ability were both strengthened through participation in the project. Additionally, the study found that working alongside STEM professionals and exposure to STEM careers were also contributing factors. The study aims to determine if increased access to technology would, in turn, increase students' self-efficacy in their technology knowledge and skills and have a positive effect on their self-confidence in STEM content. The results of the study contribute to the body of research that suggests greater access to technology may be an important factor in students' self-agency and academic achievement.

Keywords: STEM literacy**,** technological ability, critical thinking, STEM career awareness, community environmental restoration

1. Introduction

1.1 Introduced the Problem

Constant and dramatic advances in information and communication technology continue to affect each aspect of society and have important implications in the field of education. Countries are focusing on STEM education and careers to be competitive in the global economy as well as in human capital. For this reason, to remain at the forefront of the technological race, they have adopted the basic aim of raising individuals who understand science and mathematics conceptually well thus raising both economic and human capital for their countries. These students can associate these concepts with daily events through computational thinking and can solve the problems they face in daily life with the information transferred in schools (Hurt, et al., 2023). Individuals having the ability to produce knowledge and communicate this information, provide the backbone of the economy. Consequently, it is of great importance to educate each successive generation with analytical, creative, and critical thinking skills, which are called 21st-century skills. Development of these skills can be attained through STEM, the acronym for science, technology, engineering, and mathematics which is the basis of today's and all future science and technological developments. A workforce of individuals who are knowledgeable in STEM literacy, and advance their current work in the STEM field, produces innovations that will increase the business and economic stability of their countries. An increase in STEM occupations has a substantial impact on a country's ability to compete in the global digital economy (Idris, et al., 2023). People who are interested in STEM tend to take pleasure in working with ideas and hands-on problem-solving (Chiu, T.K., 2023). Early and continued experience with these realistic and investigative interests is extremely advantageous in maintaining interest in STEM fields (Zhang, Ng & Leung, 2023). To put it more succinctly, an optimum workforce is truly representative of the society in which it exists. For underrepresented portions of this workforce to become involved, they must first become aware of the opportunity, receive equitable education and skills associated with the STEM career pathway, and have a sense of truly belonging as equal members. The synergy created through this holistic approach to STEM fields is contingent on the fact that all members are fluent in STEM literacy and technological abilities.

1.2 Why is the Problem Important?

Educational technology can increase students' understanding of subject content. Improvements in educational technology have provided a plethora of opportunities to support student learning and enhance the technological ability of the learner. Students who were drawn to STEM at an early age and continued to be interested throughout high school were more likely to declare a STEM major. In addition, studies found that students who planned to major in STEM before high school graduation were more likely to persist in STEM. Higher levels of STEM engagement are found in students who report higher levels of belonging, and connections to STEM in their community (Mulvey, et al., 2023).

The International Society for Technology Education (ISTE) is at the forefront of the educational technology movement. ISTE believes that the transformation of teaching and learning, through innovation and problem-solving is dependent on the power of technology (ISTE, 2020). Teachers must develop pedagogy-oriented technology or technology-supported pedagogy to be effective in integrating technology into their instruction (Li, et al., 2019). Classroom technology that allows students to investigate problems and gather information about a topic being researched should be provided as a resource by the classroom teacher.

1.3 Primary and Secondary Hypotheses

1. Participants in the CCERS STEM + C Project will have a higher technological ability than non-CCERS participants

2. Participants in the CCERS STEM + C Project will have greater access to technology than non-CCERS participants

1.4 Explore the Importance of the Problem

For this study, technology can be nuanced into four distinctive categories:

1. Technology as a product of engineering where technological tools are designed to meet specific needs to support investigations in STEM. An example would be the use of probes.

2. Technology as educational or instructional where technology is integrated into pedagogical instruction or technology that facilitates instruction. Examples include laptops and digital notebooks.

3. Technology as Computational Thinking where technology is used in the development of computing competencies. Higher-order thinking skills such as data collecting, analyzing, problem-solving, designing, evaluating, and communicating are all elements of computational thinking. An example would be LEGO Robotics

4. Technology as Tools and Procedures used by scientists, mathematicians, and engineers. The importance of real-world, authentic problem-solving through hands-on, inquiry-based activities is the focus of this definition of technology. The work of real-life STEM professionals is dependent on STEM-specific tools and technologies. Exposing students to the authentic practices of STEM professionals enhances their understanding of the use of technology in real-world settings and promotes literacy and career awareness opportunities.

Educational attainment and academic achievement in STEM are continually being highlighted in the 21st Century. The demand for STEM professionals is projected to grow faster than other occupations (U.S. Bureau of Labor Statistics, 2021) and will contribute not only to the collective economy but will also benefit the individuals who chose this career pathway. Fifty-five percent of Black female students and 61% of Hispanic female students reported never taking an engineering or technology course, compared to only 41% of their White male peers (Change the Equation, 2016). This means that the most underrepresented group of students (women of color) in the field of STEM only learn about engineering and technology through their science coursework. This accentuates the importance of student engagement in STEM activities and technological integration in the science classroom (Ellis, et al., 2020). Students' acquisition of high-level technological skills and abilities is considered a basic part of the 21st-century curriculum, equivalent in importance to reading and writing (Unesco, 2000). Thus, current educators are obligated to use technology as a teaching tool (Haleem, et al., 2022). Across the United States school districts are making technology integration a priority and, as a result, investing significantly in both equipment and professional development for instructional technology (Gomez, et al., 2022). In the New York City Department of Education, one of the largest preK-12 public education systems in the world, Computer Science for All (CS4All) was initiated in the year 2015. The goal of the initiative is to ensure that every New York City student receives a meaningful unit of computer science education by the year 2025 (https://blueprint.cs4all.nyc/). Extensive professional development for the teachers in the NYCDOE has been provided by several institutions, none more significantly than the Curriculum and Community Environmental Restoration Project.

Arguably, no area of education has benefited more than integrated STEM learning environments. The Curriculum and Community Environmental Restoration STEM + C Project continues to work tirelessly to ensure a seamless integration of technology with the environmental restoration of New York Harbor. During its initial iteration, the five pillars of the CCERS STEM + C Project – (I) Teacher Training Curriculum, (II) – Student Learning Curriculum, (III) – Digital Platform, (IV) – Afterschool and Summer Mentoring & (V) – Community Restoration-Based Exhibits, offered the fundamentals of a multifaceted program that emphasized a long term problem-based environmental restoration project to middle school students in the New York City public schools. Many of these students live in high-poverty communities and represent underserved and underrepresented populations. The success of the initial program and some of the challenges prompted the expansion of the program, both in depth and in breadth. Since this project is dynamic, each of the pillars has been greatly expanded throughout the project, as can be seen in Figure 1. The CCERS STEM + C Project continues to offer an environmental restoration learning setting supported by technology and integrating STEM content. Students are equipped with web-based databases, an extensive STEM curriculum, and interactive and immersive technology to address real-world problem-solving and environmental justice issues that are prevalent throughout the city. It motivates students to challenge social issues, have a voice in environmental decisions, and become stewards of New York Harbor and its surrounding waterways. Learning technologies have been demonstrated to enhance student learning, engagement, and interest in mathematics and science (Hillmayr, et al., 2020)

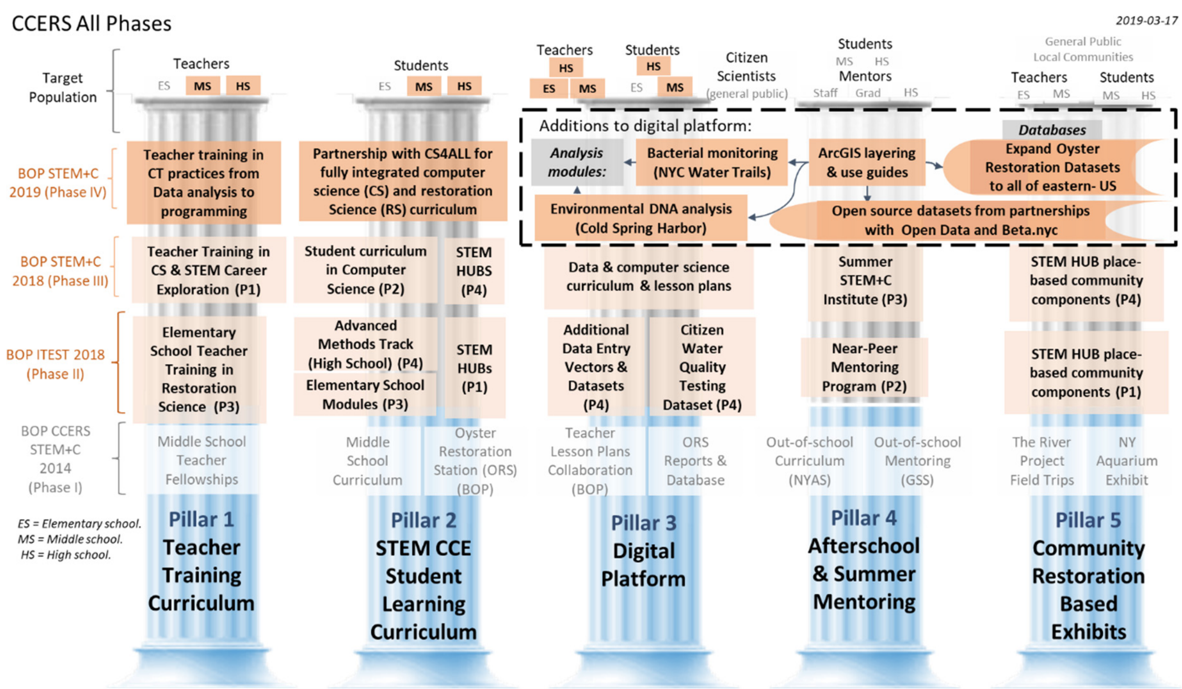


Figure 1. The Five Pillars of the CCERS Project Including All Expansions of the Program

For this study, particular emphasis is being given to Pillar III - The digital platform. This web-based, open-access platform serves a multitude of purposes and is an integral part of the CCERS STEM + C Project. The digital repository was created for sharing materials and data among teachers, students, and citizen scientists and promotes cross-institutional learning and student engagement. This platform provides students access to learning resources they wouldn't otherwise have and brings to students the collaborative nature of science. Measurements and observations from restoration stations are uploaded from the field or when students return to their classrooms (See

Figure 2). This database is used to make comparisons across school sites and time points which allow participants to understand similarities or differences in observations at different points in time to enhance experiential learning.

Student collaborations as demonstrated in this project involve problem identification, data analysis, and problem-solving activities using computer software which according to research sources contributes to developing data collection and analysis skills (Reid-Griffin & Carter, 2008). Educators use the materials and data accessed through the digital platform to inform curricula design, by learning from other educators and participants in the process. Digital technologies can provide new ways of engaging students in environmental stewardship and can pique student interest while enabling them to capture experiences of local environments, collect data, and share their findings with broader audiences (Buchanan, Pressick-Kilborn & Maher, 2018).

As with all of the pillars, this is an evolving and dynamic component. General access to the site is open to all of the stakeholders as well as the public. Selected sections such as curriculum access are reserved for the educators in the program. Many of the research topics presented at the Annual Science Symposium are gleaned from this resource. Web-based learning is a vital tool in education, providing information, enhancing communication, providing an environment for creativity, and delivering instruction (Dinc, 2017). Students' understanding of subject content can be increased with the use of technology (U.S. Department of Education, 2017). Inquiry-based learning involves making predictions, investigating, evaluating, and developing explanations (Spektor-Levy, et al., 2017). A web-based platform can be used to support student inquiry and provide a means for practice investigation and explanations of phenomena while developing an understanding of instructional technology.

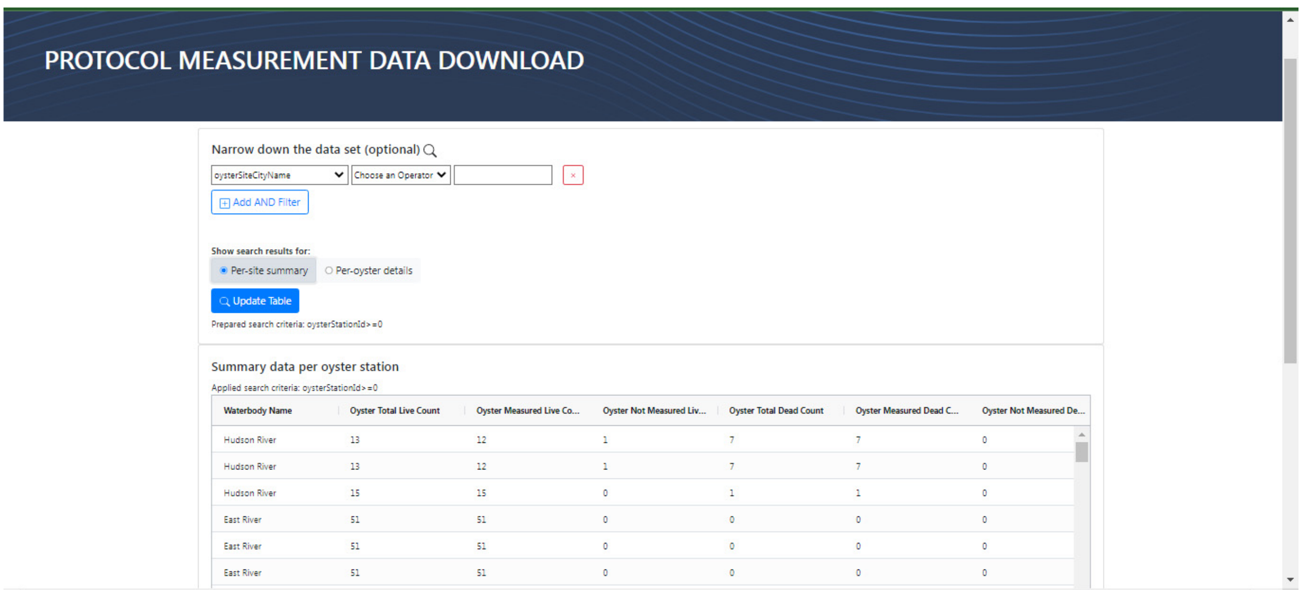


Figure 2. Sample Metric Section from the BOP Platform
https://bopuiprod.azurewebsites.net/data/download-measurement

The use of technology and subject content mutually influence one another (Dong, et al., 2019). In a technology-supported, integrated STEM learning environment, technology, content learning, and professional career training often become intertwined and inseparable (Yang & Baldwin, 2020).

2. Method

2.1 Research Design

This study used a post-test-only comparison group design. Students who attended events that included the CCERS curriculum were defined as the experimental group and students who attended events but did not participate in the CCERS curriculum were considered the comparison group. At first, participants were randomly assigned to be in the experimental or comparison group, but as of 2020, the control group is no longer in use, meaning all new participants since 2020 are in the experimental group.

2.2 Sampling Procedure and Participants

This report includes survey 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. Student demographic breakdowns are as follows: 29% of students identified as female, with 27% identifying with a URM,(Note 1) 17% identified as first-generation American, and grade levels ranged from 6th through 12th grade. Almost all students were from New York, however, three students were from New Jersey, three were from Pennsylvania, and one was from Nevada. The respondent demographics can be seen in Table 1.

Table 1. Demographics of Survey Participants

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			
American 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 (7.6%)	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%)	17 (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 Measures

Unless otherwise stated, composite scores are the mean scores with missing variables removed. For each of the research questions, indices were created by averaging items on the survey's subscales. Where appropriate, the research team calculated Cronbach's alpha,(Note 2) a measure of internal consistency, to show that seemingly disparate questions do go together.

Technological ability

Technological ability was a self-reported measure of participants' agreement with the following statements:

- I feel comfortable using software programs
- I use software programs in school that allow me to collect data
- I feel comfortable using the Internet for research, to find primary sources, or to look up sources to use for papers or projects
- My teachers expect me to use websites to do my schoolwork
- For part of my school day, I use a computer or tablet, or I go online to do work in class

The response options were "strongly disagree," "disagree," "maybe," "agree," and "strongly agree," which were coded as 1-5, respectively. Lower scores represent lower perceived ability in technology and higher scores represent higher perceived ability in technology. Internal consistency reliability was acceptable with Cronbach's alpha of 0.79.

Access to technology

Access to technology was a self-reported measure of how much access students had to computers, tablets, and smartphones. They were presented with the following statements:

- I have access to a computer that I can use at home
- I have access to a tablet that I can use at home

- I have access to a smartphone

Response options were “less than once a month” (1), “once a month” (2), “once a week” (3), "once a day” (4), and "multiple times a day” (5). The values were added together so that lower scores represent less access to technology while higher values represent more access to technology. Because this was simply a measure of whether students had access to technology, internal consistency wasn’t calculated.

2.4 Data Collection Procedure

Data were collected via a survey on Alchemer, (https://www.alchemer.com/), a survey design and distribution website. The research team provided partners with a general survey link that any activity participant could access. The survey procedure included screening questions to ensure students met participation requirements, parental consent form, student assent form, program evaluation survey, and the research survey for the current study. The research survey took participants an average of 8 minutes to complete.

2.5 Analysis

Advanced statistical analysis techniques including linear regression models, logistic regression, and mediation models were used. Bootstrapping was applied to deal with outliers, non-normal distribution of the data, and large amounts of missing data. Significant results are denoted with an (*).

Each type of analysis was conducted twice: once for the overall dataset, which has all students; and again, with only students who identified with an underrepresented minority (URM). This was done to see if results from the overall dataset applied equally to students who may have historically been overlooked.

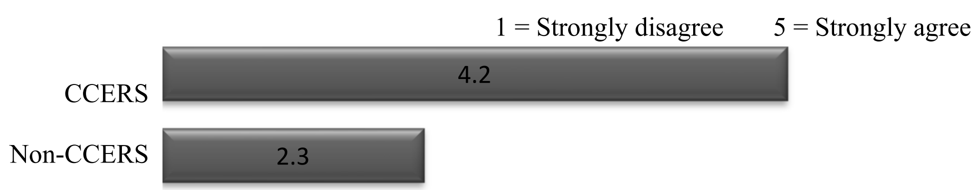
3. Results

3.1 Impact on access to Technology and Technological Ability

Analysis indicated that students who participated in the CCERS curriculum had significantly higher scores in technological ability than non-CCERS students [CCERS M = 4.2 (SD = 0.6) vs non-CCERS M = 2.3 (SD = 1.2)]*. When breaking down the technological ability score to look at each statement, analyses showed CCERS students agreed more with each statement (described above under Measures) when compared to non-CCERS students.

Average technological ability scores among CCERS (n= 260) and non-CCERS (n= 3) students

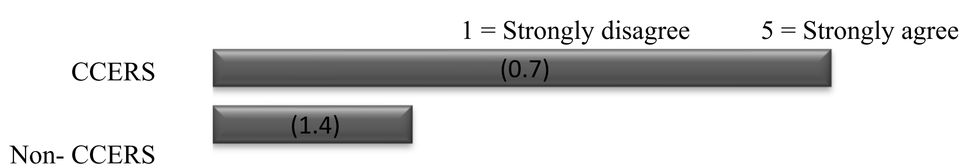
Mean (SD)



These results seem to apply consistently to subgroups. URM students who participated in CCERS curriculum had higher scores in technological ability than non-CCERS URM students [CCERS M = 4.1 (SD = 0.7) vs non-CCERS M = 2.0 (SD = 1.4)] *.

Average technological ability scores among CCERS URM (n= 103) and non-CCERS URM (n= 2) students

Mean (SD)



Students who participated in CCERS also reported having greater access to technology than non-CCERS students [CCERS M = 4.2 (SD = 0.6) vs non-CCERS M = 2.3 (SD = 1.2)] *. Because these two conceptually seem to be related, a mediation model was created and tested.

Figure 3. Mediation Model for Access to Technology

The mediation model (see Figure 3) shows that CCERS participation may have given students more access to technology, in part, by improving students' technological ability. This model is even generalized to URM students, showing how the program can equitably distribute benefits so that all students can prosper. What this means is that CCERS may have provided students with more resources, as well as the means to utilize them. In the future, this is important, as solely providing students with computers, smartphones, and tablets may not alone improve outcomes. Students must also be given training to increase their technological ability so they can use these tools effectively.

However, separate analyses revealed that CCERS students had greater technological ability than non-CCERS students, and students with higher technological ability were more likely to have higher science self-efficacy (See Figure 4). This paints an image of a student who participated in CCERS: improved technological ability may have helped them do things that made them feel more like a scientist, which made them feel more confident about STEM activities and careers (i.e., their science self-efficacy).

This relationship holds for URM students, except that the strength of the relationship between CCERS participation, technological ability, and science self-efficacy was stronger. This suggests that by changing the way students engage with technology, CCERS was able to have an indirect impact on students' perceptions of their ability to solve problems and engage in STEM, including URM students.

Figure 4. Mediation Model for Science Self-Efficacy

3.2 Moderation Analysis

An exploratory moderation analysis was performed to identify areas for improvement and intervention for future iterations of the program. There was a strong association between science self-efficacy and technological ability that warranted further investigations. It was found that awareness of STEM careers moderated the relationship between science self-efficacy and technology ability. This means that a higher awareness of STEM careers makes the relationship between science self-efficacy and technology ability stronger, while less awareness of STEM careers can lead to their relationship being weaker (See Figure 5).

Figure 5. Factors That Support Technological Ability

4. Discussion

As CCERS STEM + C promotes technological ability in students, it seems that the increase in technological ability helps build science self-efficacy. Studies have shown that technology helps to improve students' science learning, increasing their sense of competency (Reid-Griffin & Carter, 2008). This may improve students' learning overall, as incorporating new information technologies may lead to more efficient and effective education (Lòpez-Pèrez, et al., 2013). It is also possible that tools given to students to solve problems can help build their sense of competency (Wang, et al., 2022). Given competency is a key to motivation, this may be one way to CCERS STEM + C program gets students to become interested in STEM careers.

In addition, there is evidence that the CCERS STEM + C program impacts STEM career awareness. This seems to be a direct result of Pillar 1: Teacher Training with Computer Science, Data Science, and STEM Career Exploration, as one of the pillar's goals, was for teachers to increase student engagement and learning in oyster restoration research, and interest in STEM careers. Additionally, teachers predicted that students' awareness of STEM careers would increase as a result of participating in the BOP activities, as they were acting as scientists themselves and were collecting and working with computer data, a prediction that is supported by the data.

Lastly, the moderation model showing awareness of STEM careers moderates the relationship between science self-efficacy and technological ability and sheds light on a way to improve the program. It may be that when students know the purpose of their activities, ideas can translate into action. This is consistent with self-determination theory (Ryan & Deci, 2000). Specifically, students knowing they can make a career out of their skills may act as a catalyst in motivating them to improve their technological abilities. STEM education is universal; and focuses on literacy skills such as creative thinking, critical thinking, problem-solving, and collaborative work. These skills must be acquired by the individual. STEM education paves the way for being creative, productive and thinking critically, and analytically in the field of science, technology, engineering, and mathematics (Karasah-Cakici, Kol, & Yaman, 2021).

The study found that students who participate in through technology-enhanced real-world STEM experiential learning, have developed confidence in their technological ability as well as their STEM content knowledge. The project provides student engagement in oyster restoration in the New York Harbor by building expertise in oysters and oyster restoration, developing student technological and research skills through the oyster restoration activities, and encourages students to hone and expand these new skills by seeing themselves as scientists (Birney, et al., 2023). Through engagement with the embedded technology, students can to succeed in their STEM coursework which enhances their awareness of further STEM educational and career opportunities. It opens the gateway for the STEM pipeline to continue.

5. Conclusion

Education is one of the most important and difficult endeavors a society can pursue. The motivation and strategies elicited by students, such as content knowledge and interest are crucial to students' success and tenacity (Dinsmore & Fryer, 2019). Academic success is contingent on many varied factors including engagement and incremental successes (Harackiewicz, Smith, & Priniski, 2016). Some groups of students (marginalized/underrepresented), benefit when the emphasis of the STEM topic is giving back to the community (Thoman, et al., 2015). Intrinsic motivation is based on three psychological needs. Autonomy or internal self-approval, competence or self-efficacy and a connection to others are critical for success (Szulawski, Kaźmierczak, & Prisik, 2021).

The results of the study support the original hypotheses and have implications for further research. Students who participated in the CCERS activities showed a higher level of confidence in their scientific observations, inquiries, and communication compared to students who did not participate in the CCERS activities. Additionally, CCERS students had higher technological ability scores than non-CCERS students, and this explained some of the project's influence on science self-efficacy. Lastly, the program's influence on technological ability and science self-efficacy is related to students' career interests. The result of these analyses seems to hold for URM (Underrepresented Minority) students when there is enough data to perform the analysis, meaning, the results may be equitably distributed throughout the student population. As students develop their science self-efficacy and gain interest in STEM careers, they may be more likely to pick a STEM major in college (Estrada, Hernandez, & Schultz, 2018). The results show that the CCERS STEM + C program may be a part of the pipeline to bring students into STEM.

The data suggests several opportunities for the modification to CCERS program for further research. One approach would be to target URM students with a low interest in STEM content and limited access to technology. Bolstering the amount of technology in the STEM content to be learned would enhance the learning environment with implications for greater self-efficacy and success. 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 schools can implement that may directly benefit students. CCERS can also ensure that students are made aware of the opportunities they have for STEM careers. Exposure of the students to careers in the fields associated with STEM can pique their awareness of and interest in STEM careers (Blotnicky, et al., 2018). This may help promote more learning among those who already see themselves as competent in science and promote further growth in this area. Future research is needed to explore the relationship between interest, self-efficacy, and success in pursuing postsecondary STEM education and careers.

References

Birney, L.B., Evans, B.R., Solanki, V., Mojica, E-R., Scharff, C. & Kong, J. (2023). The Billion Oyster Project and Curriculum and Community Enterprise for Restoration Science Curriculum: STEM + C Summer Institute Experiential Learning. *Journal of Curriculum and Teaching, 12*(3), 207-215. https://doi.org/10.5430/jct.v12n3p207

Blotnicky, K. A., Franz-Odendaal, T., French, F., & Joy, P. (2018) A study of the correlation between STEM career knowledge, mathematics self-efficacy, career interests, and career activities on the likelihood of pursuing a STEM career among middle school students. *International Journal of STEM Education, 5*(22), 1-15. https://doi.org/10.1186/s40594-018-0118-3

Buchanan, J., Pressick-Kilborn, K., & Maher, D. (2018). Promoting Environmental Education for Primary School-aged Students Using Digital Technologies. *EURASIA Journal of Mathematics, Science and Technology Education, 15*(2), 1-15. https://doi.org/10.29333/ejmste/100639

Change the Equation. (2015). Solving the Diversity Dilemma: Changing the Face of the STEM Workforce, Vital Signs: Reports on the Condition of STEM Learning in the U.S., Retrieved from http://files.eric.ed.gov/fulltext/ED564127.pdf

Chiu, T. K. F. (2023) Using self-determination theory (SDT) to explain student STEM interest and identity development*. Instructional Science, 51*(4). https://doi.org/10.1007/s11251-023-09642-8

Dinc, E. (2017). Web-based Education and Accessibility. *International Journal of Technology in Education and Science, 1*(1), 29-35. Retrieved May 31, 2023 from https://www.learntechlib.org/p/207273/.

Dinsmore, D. L., & Fryer, L. K. (2019). Developing Learners' Cognitive Strategies and the Motivation to Use Tem: Rethinking Educational Policy*, Policy Insights from the Behavioral and Brain Sciences, 6*(2). https://doi.org/10.1177/2372732219860862

Dong, Y., Xu, C., Chai, C. S., & Zhai, X. (2019) Exploring Structural Relationship Among Teachers' Technostress, Technological Pedagogical Content Knowledge (TPACK), Computer Self-efficacy and School Support. *The Asia-Pacific Education Researcher, 29*, 147-157. https://doi.org/10.1007/s40299-019-00461-5

Ellis, J., Wieselmann, J., Sivaraj, R., Roehrig, G., Dare, E., & Ring-Whalen, E. (2020). Toward a productive definition of technology in science and STEM education. *Contemporary Issues in Technology and Teacher Education, 20*(3). Retrieved from https://citejournal.org/volume-20/issue-3-20/science/toward-a-productive-definition-of-technology-in-science-and-stem-education

Estrada, M., Hernandez, P. R., & Schultz, P. W. (2018) A longitudinal study of how quality mentorship and research experience integrate underrepresented minorities into STEM careers. *CBE—Life Sciences Education*, *17*(1), ar9. https://doi.org/10.1187/cbe.17-04-0066

Gomez, F. C., Trespalacios, J., Hsu, Y- C., & Yang, D. (2022). Exploring teachers' technology integration self-efficacy through the 2017 ISTE Standards. *TechTrends, 66*, 159-171. https://doi.org/10.1007/s11528-021-00639-z

Haleem, A., Javaid, M., Qadri, M. A., & Suman, R. (2022). Understanding the role of digital technologies in education: A review. *Sustainable Operations and Computers, 3*, 275-285. https://doi.org/10.1016/j.susoc.2002.05.004

Harackiewicz, J. M., Smith, J. L., & Prinski, S. J. (2016). Interest Matters: The Importance of Promoting Interest in Education. *Policy Insights in Behavioral Brain Science, 3*(2), 220-227. https://doi.org/10.1177/2372732216655542

Hillmayr, D., Ziernwald, L., Reinhold, F., Hofer, S. I., & Reiss, K. M. (2020). The potential of digital tools to enhance mathematics and science learning in secondary school: A context-specific meta-analysis. *Computers & Education, 153.* https://doi.org/10.1016/j.compedu.2020.103897

Hurt, T., Greenwald, E., Allan, S., Cannady, M., Krakowski, A., Brodsky, L., Collins, M.A., Montgomery, R., & Dorph, R. (2023). The computational thinking in science (CT-S) framework: operationalizing CT-S for K-12 science education researchers and teachers. *International Journal of STEM Education, 10*(1). https://doi.org/10.1186/s40594-022-00391-7

Idris, R., Govindasamy, P., Nachiappan, S., & Bacotang, J. (2023). Revolutionizing STEM Education: Unleashing the Potential of STEM Interest Careers in Malaysia. *International Journal of Academic Research in Business & Social Sciences, 13*(7). https://dx.doi.org/10.6007/IJARBSS/v13-i7/17608

International Society for Technology in Education (2020). Be bold with us. Retrieved from https://www.iste.org/about/about-iste

Karasah-Cakici, S., Kol, O., & Yaman, S. (2021). The Effects of STEM Education on Academic Achievement in Science Courses: A Meta-Analysis. *Journal of Theoretical Education Science, 14*(2), 264-290. https://doi.org/10.30831/akukeg.810989

Li, Y., Garza, V., Keicher, A., & Popov, V. (2019). Predicting High School Teacher Use of Technology: Pedagogical Beliefs, Technological Beliefs and Attitudes, and Teacher Training. *Technology, Knowledge and Learning, 24*, 501-518. https://doi.org/10.1007/s10758-018-9355-2

Lòpez-Pèrez, M. V., Pèrez-Lòpez, M. C., Rodrìguez-Ariza, L., & Argente-Linares, E. (2013). The influence of the use of technology on student outcomes in a blended learning context. *Educational Technology Research and Development*, *61*(4), 625-638.

Mulvey, K.L., Cerda-Smith, J., Joy, A., Mathews, C., & Ozturk, E. (2023). Factors that predict adolescents' engagement with STEM in and out of school. *Psychology in the Schools, 60*(9), 3129-3665. https://doi.org/10.1002/pits.22946

Reid-Griffin, A., & Carter, G. (2008). Uncovering the potential: the role of technologies on science learning of middle school students. *International Journal of Science and Mathematics Education, 6*(2), 329-350. https://doi.org/10.1007/s10763-007-9105-8

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-78. https://doi.org/10.1037/0003-066X.55.1.68

Spektor-Levy, O., Israeli, N., Plutov, I., & Perry, N. (2017). *Integrating Technology in Preschool Science and Inquiry*. In Book: Digital Tools and Solutions for Inquiry-Based STEM Learning, IGI Global: Hershey, PA. https://doi.org/10.4018/978-1-5225-2525-7.ch001

Szulawski, M., Kaźmierczak, I., & Prisik, M. (2021). Is self-determination good for your effectiveness? A study of factors which influence performance within self-determination. *PLoS One, 16*(9). https://doi.org/10.1371/journal.pone.0256558

Thoman, D. B., Brown, E. R., Mason, A.Z., Harmsen, A. G., & Smith, J. L. (2015). The role of altruistic values in motivating underrepresented minority students for biomedicine. *BioScience. 65*, 183-188. https://doi.org/10.1093/biosci/biu199

U.S. Bureau of Labor Statistics (2021). *Employment in STEM occupations.* U.S. Bureau of Labor Statistics. Retrieved from https://www.bls.gov/emp/tables/stem-employment.htm

U.S. Department of Education. (2017). Use of technology in teaching and learning. Retrieved from https://www.ed.gov/oii-news/use-technology-teaching-and-learning

Unesco (2000). *Informatics for secondary education. A curriculum for schools*. Paris: Unesco.

Wang, C., Cho, H. J., Wiles, B., Moss, J. D., Bonem, E. M., Li, Q., Lu, Y., & Levesque-Bristol, C. (2022). Competence and autonomous motivation as motivational predictors of college students' mathematics achievement: from perspective of self-determination theory. *International Journal of STEM Education, 9*(41).

https://doi.org/10.1186/s40594-022-00359-7

Yang, D., & Baldwin, S. J. (2020). Using Technology to Support Student Learning in an Integrated STEM Learning Environment. *International Journal of Technology in Education and Science, 4*(1), 1-11. https://doi.org/10.46328/ijtes.v4i1.22

Zhang, Y., Ng, O.-L., & Leung, S. (2023). Researching Computational Thinking in Early Childhood STE(A)M Education Context: A Descriptive Review of the State of Research and Future Direction. *Journal for STEM Education Research, 6*, 427-455. https://doi.org/10.1007/s41979-023-00097-7

Notes

Note 1. Underrepresented minorities include those identifying as American Indian or Alaska Native, Black or African American, and Hispanic/Latino.

Note 2. Cronbach's alpha is a measure of how two or more questions fit together, expressed as a value between 0 and 1. Generally speaking, values below 0.7 mean internal consistency is too low, meaning the questions are measuring different things rather than capturing one thing from multiple angles. On the other hand, values above 0.9 are considered high, meaning the same questions are being asked over and over again without adding a lot of value. What is generally accepted, therefore, is a value above 0.7 and below 0.9.

Acknowledgments

Not applicable.

Authors contributions

Not applicable.

Funding

Not applicable.

Competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Informed consent

Obtained.

Ethics approval

The Publication Ethics Committee of the Sciedu Press.

The journal's policies adhere to the Core Practices established by the Committee on Publication Ethics (COPE).

Provenance and peer review

Not commissioned; externally double-blind peer reviewed.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.