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Researcher, PI and CEO - Managing a Large Scale Environmental Restoration Project in New York City; Creating Expectations, Establishing Structure, Protocols and Realistic Outcomes

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Abstract

Research consistently shows that children who have opportunities to actively investigate natural settings and engage in problem-based learning greatly benefit from the experiences? This project developed a model of curriculum and community enterprise to address that issue within the nation's largest urban school system. Middle school students will study New York Harbor and the extensive watershed that empties into it, as they conducted field research in support of restoring native oyster habitats. The project builds on the existing Billion Oyster Project, and was implemented by a broad partnership of institutions and community resources, including Pace University, the New York City Department of Education, the Columbia University Lamont-Doherty Earth Observatory, the New York Academy of Sciences, the New York Harbor Foundation, the New York Aquarium, and others. The project model includes five interrelated components: A teacher education curriculum, a digital platform for project resources, museum exhibits, and an afterschool STEM mentoring program. It targets middle-school students in low-income neighborhoods with high populations of English language learners and students from groups underrepresented in STEM fields and education pathways. This paper explores the management of this large-scale project and provides insight with regard to the governance of the various project components.

Keywords: *project-based learning, environmental restoration, educational technology*

1. Project Summary

1.1 Project Summary

The ***"Curriculum and Community Enterprise for the Restoration of New York Harbor with New York City Public City Schools"*** is both an education and restoration initiative. The project begins with the vision that public school curricula; particularly in STEM-C content areas, can be enhanced by explicitly linking teaching and learning to a localized environmental science project that demands authentic research, data collection, and experimentation. In New York City there are numerous local environmental problems that merit inquiry based science research by students; however none is more fundamental than the question of human impact on our watershed. The Billion Oyster Project provides the original vision and framework by which the project operates and functions https://www.billionoysterproject.org/.

New York City is the terminus of a regional watershed that encompasses more than 17,000 square miles, four states, and approximately 20 million people. When the water of the combined Hudson, Raritan, and Bronx River watershed arrives in New York Harbor it meets the Atlantic Ocean and forms one of the largest and the majority of well-protected natural harbors in the world. The 300-square mile estuary that surrounds and comprises New York City was, at the time of European arrival, also one of the most biologically productive and resilient ecosystems on the planet. For more than 250 years the vast fisheries of the Upper New York Bay and Hudson River both nourished the people and propelled the wealth of the city. Arguably no species was more essential—or more abundant—in the building New York City than the native East Coast oyster, Crassostrea virginica. The historical extent of the New York Bay oyster included more than 200 square miles of reef and hundreds of billions, if not trillions of individuals. At this scale the oyster was inarguably the original ecosystem engineer of New York Harbor. Its power to attenuate waves, continuously filter impurities, and shelter complex communities of marine life is unmatched and irreplaceable. To restore the harbor is to restore this keystone species (Kulansky, 2008).

The Curriculum and Community Enterprise for Restoration Science (CCCERS) is a model to involve a significant percentage of New York City's 1.1 million public school students in this process. The result will be to create an innovative STEM-C curriculum for teachers; a meaningful, highly engaging basis of learning for students; and a unifying platform around which to engage a diverse community of STEM-C professionals, graduate and postdoctoral scientists, and out-of-school time (OST) educators in carrying out an array of complementary education and restoration activities (Mueller, 2012). The process of keystone species restoration is necessarily multidisciplinary, hands-on, and scientific. In the case of oysters in New York Harbor—other regions, other species, other disciplines—the undertaking requires the expertise of biologists, ecologists, engineers, oceanographers, and computer scientists working collaboratively in classroom, laboratory, and field settings. In the formal school and afterschool-based curriculum at the foundation of the CCERS project these diverse disciplines are anchored in strict core competencies of science and mathematics (http://www.nsf.gov/awardsearch/showAward?AWD_ID=1440869). One of the main focus of the project is also incorporating citizen science as an ongoing movement through large urban environments (Calabrase-Barton, 2012).

1.2 Research Plan and Goals

The three main research goals of the CCERS Project are: 1) Increase public middle school student access to high quality, engaging and authentic STEM-C learning in both formal and informal settings, thereby (a) increasing student STEM-C content knowledge; (b) improving student self-efficacy and confidence in STEM-C; and (c) presenting students with new role models from STEM-C related career fields.

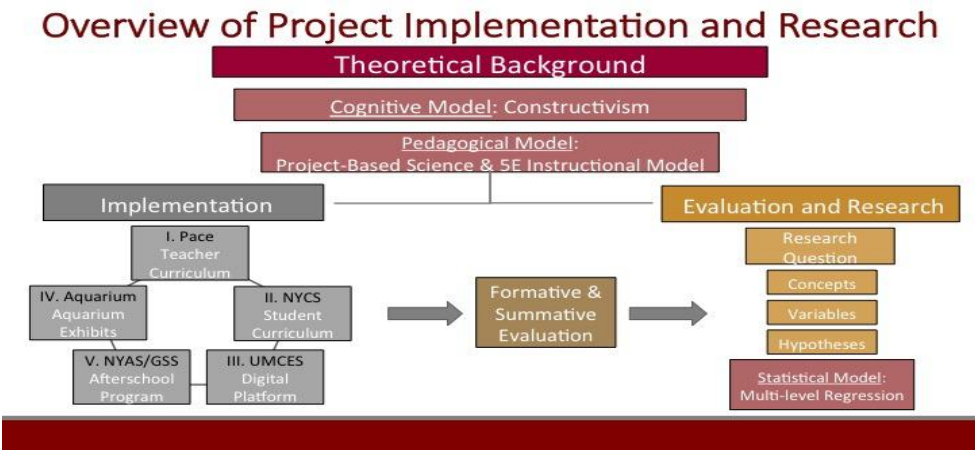

Figure 1.0 *depicts a summary of the projects overall Research and Implementation Plan*

Figure 2.0 *addresses the Research outcomes and variables*

The following provides a brief summary of the CCERS research findings thus far on the project:

Goal 1 – The Educational Model: Increase the quality and effectiveness of STEM-C teaching and learning for middle school students of urban public schools.

a. Assess the impact of teaching authentic field science using an integrated curriculum and community enterprise model.
b. Develop an educational model that incorporates community-based restoration science into public school education that is scalable, replicable, and sustainable.

Goal 2 – Teachers: Increase knowledge and instructional skill of teachers, informal educators, and STEM-C professionals who work in economically disadvantaged neighborhoods.

a. Increase educators' knowledge of STEM-C content
b. Increase educators' knowledge and skill in teaching inquiry-based restoration-oriented lessons and activities
c. Improve educators' frequency and perceived efficacy in the use technology, scientific equipment and project-generated data

Goal 3 - Students: Increase public middle school students' knowledge of and interest in STEM-C.

a. Increase student STEM-C perceived content knowledge and skills.
b. Improve student confidence in learning and applying STEM-C knowledge.
c. Increase students' knowledge of and exposure to possible STEM-C career pathways.

Research Questions	Research Outcomes
1. Do the five programmatic pillars function independently and collectively as a system of interrelated STEM-C content delivery vehicles that also effectively change student and educator disposition toward STEM-C learning and environmental restoration and stewardship?	• Development of the Educational Model has been assessed through Social Network Analyses of survey and interview data illustrating growth in **scale** of interactions among and between pillars: ○ **Integrated curriculum** developed in Teacher Fellowship (Pillar 1) is being tested and refined by Cohorts 1 & 2 along with curriculum development experts from the New York Harbor Foundation (NYHF). ○ Lessons and activities using Bybee's 5E structure are available to Cohorts 1 & 2 and others on the Digital Platform (Pillar 3) ○ **Community enterprise collaboration** between The New York Academy of Sciences (NYAS) and Good Shepherd Services (GSS) (Pillar 4) has produced, tested, refined, and implemented multiple lessons and activities for afterschool programs with uncertain resources. ○ **Community-based restoration science** is being conducted in field day activities (Pillar 2) and taught in hands-on field trips and class visits by The River Project (TRP) (Pillar 5). • Research team had implemented **Project Sustainability Assessment Tool** and reported on baseline and year-one progress to assess sustainability on a standardized instrument to enable project leaders to see growth and provide direction for further improvement. • Research team has provided answers in response to Principal Investigator (PI) inquiry regarding ideas for **replicating** project in other settings, with other species/settings requiring restoration to support project's two-year extension.
2. What comprises the "curriculum plus community enterprise" local model?	• Cohort 1 & 2 (Pillar 1) teachers' knowledge and instructional skill are increasing through fellowship and interactions: ○ Research team implemented Discussion Questions to assess teachers' efficacy at baseline and end of year one. Qualitative responses will be compared to objective and quantitative data provided by evaluation team. • The New York Academy of Sciences & Good Shepherd Services (Pillar 4) have developed training program for mentors and are incorporating one another's expertise to continuously improve lesson implementations and provide curriculum to greater numbers of students in afterschool/out-of-school settings. • The River Project conducts field trips with BOP-relevant hands-on-minds-on activities for students of teachers in Pillar 1 and in afterschool/out-of-school programs with Pillar 4.
3. What are mechanisms for creating sustainability and scalability of the model locally during and beyond three-year implementation?	• Project **Sustainability** Assessment indicates growth and progress between baseline and end of year one. Results will be discussed with or by leadership team. Research team will implement again for longitudinal comparison at end of year 2. • **Scalability** research via surveys and interviews to produce Social Network Analysis indicates that the project is achieving increasingly synergistic results within and between pillars. •

4. What core aspects of the model are replicable?	• **Pillar 1:** The Teacher Training Fellowship at Pace University could be implemented with different cohort of urban middle school teachers to create curriculum in different city and/or for different restoration project. • **Pillar 2:** Curriculum could be implemented with students at different schools, and/or revised to be suitable for different grade levels. • **Pillar 3:** Structure is in place and could store new sets of lessons for new Pillar 1 & 2 partners. • **Pillar 3:** Digital platform could expand to archive Pillar 4 lessons. • **Pillar 4:** NYAS could provide lesson plans and training to other afterschool and/or out-of-school educators (e.g., Boys & Girls Clubs). • **Pillar 5:** Other restoration sites and community partners could develop exhibits relevant to current project and/or new restoration science project.

2. The Project Management and Organization

For organizational procedures the project has found it most useful to use *Smartsheets* for tracking progress and daily organization. Given the magnitude of this project, it is a necessary component. This enables all personnel to have an idea of what is taking place, where it is taking place and under what specific pillar. This enables all personnel to be immersed in the project at all times. It has proven to be very useful and beneficial. These charts also assist in the overall project management, design and facilitation and the deliverables and outcomes anticipated by the project.

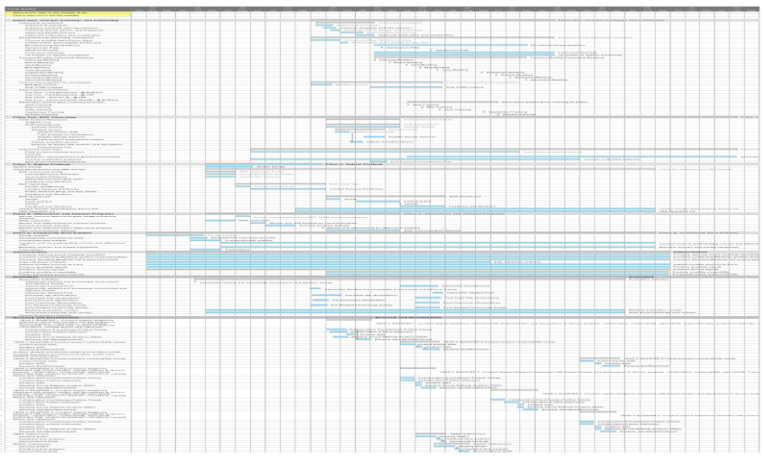

Figure 3.0 Sample CCERS Smartsheet Sample

3. Administrative Demands for Prime Institution

3.1 Finance, Legal, Budget, Administration, Office of Sponsored Research

Establishing procedures and protocols for the prime institution has been critical. There is a tremendous amount of paperwork, due diligence, contract review, budgeting and finance protocols that need to be implemented. Establishing realistic time frames, delivery of funding and reimbursements, sub-award agreement, contract reviews and following federal guidelines all must be considered, protocols designed and coordinated with each of the 10 partner institutions. This component of the work tends to be very time consuming so the tighter and more structured the protocols the more quickly that this will flow. An organizational chart was also established to assist with duties and responsibilities taken on by each of the institutions. (See Figure 4.0)

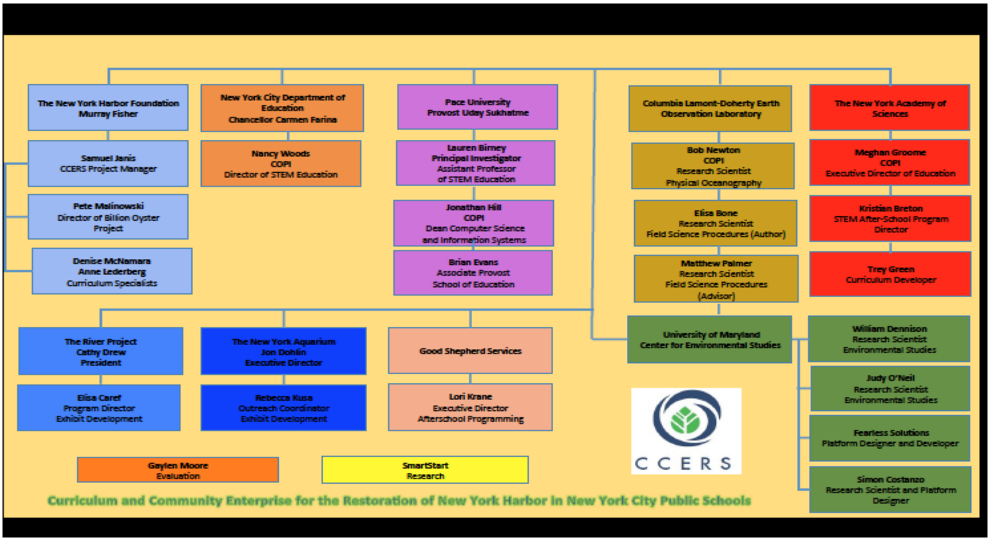

Figure 4.0 Multi Institutional Organizational Chart

4. Compelling Progress and Forward Movement

4.1 Environmental and Social Impacts

"The Environmental Restoration of New York Harbor through Curriculum and Community Enterprise" anticipated social impacts are listed below:

- Addressing the needs of the underserved diverse population of New York City
- Integration of Environmental Restoration, Citizen Science, and Project- Based Learning
- Creating clean water for New York Harbor; in alignment with the Clean Water Act
- Restoring New York Harbor with the Keystone Species of Oysters

- Creating opportunities for New York City students to participate in Citizen Science while restoring New York Harbor
- Allowing Public School Teachers to create meaningful curriculum for their students that allows them to have access to New York waterways while conducting Research
- Establishing a unique opportunity for teachers to work with Scientists and Science Educators to create an integrated project based learning curriculum for middle schools students
- Promote Growth in the STEM fields at an early age through unique middle school experiences

As the project continues to move forward, we anticipate expanding upon these aspects on a larger scale. Creating opportunities for students to participate in projects with a restoration focus allows for them to take ownership of their community and establish a sense of purpose within their community as well.

5. Capitalizing on Project Success

5.1 Product Design and Deliverables

The Curriculum and Community Enterprise for Restoration Science (CCERS) facilitates partnerships between scientists and middle school educators on ecological restoration and environmental monitoring projects. The educational model implemented at Pace University is designed to "wrap around" the student, including classroom instruction, field science, after-school programs and engagement with the student's community. Its "pillars" include: a teacher training fellowship, student curriculum, a digital platform, afterschool and summer mentoring, and community exhibits. The digital platform includes a tablet app tailored to the project's field protocols and linked to a database shared across schools and partnering institutions. Through the digital platform, data is integrated into a single citizen-science monitoring project, teachers share curriculum and best practices, and students can link directly to their peers in other schools. Curriculum development has been collaborative between scientists, science education specialists, and secondary school teachers. The CCERS is deeply rooted in project-based learning: the New York Harbor School has engaged high school students in environmental monitoring and oyster restoration in the Harbor for about the last decade. The science partners (University of Maryland and Columbia Lamont-Doherty Observatory) have been working with students and other citizen scientists in outdoor science over about the last decade. Local partners in outside-the-classroom education include the New York Academy of Sciences, The River Project, which will provide field education services, and Good Shepherd Services, which provides after-school programming in schools serving primarily poor families. Scientists on the project engage directly with teachers and informal educators in curriculum development and citizen-science outreach. The New York Aquarium will host a permanent exhibit that depicts components of the project and the activities in the environmental restoration of New York Harbor.

6. Conclusion

The STEM-C Curriculum and Community Enterprise for New York Harbor Restoration in New York City Public Schools (STEM CCCERS), will make the Billion Oyster Project accessible to 40 or more additional schools, 80 teachers, and at least 8,640 students. The project consists of five distinct resource pillars that when combined in practice will foster direct collaboration between teachers and STEM-C professionals, innovative methods for teaching STEM-C in schools, complementary afterschool curriculum, and aquarium-based programing. Pillar One is the teacher training program at Pace University, engaging cohorts of 20 teachers in institutes for curriculum writing and field class methodology; monthly workshops for collaboratively evaluating and creating curriculum; monthly webinars led by STEM-C professionals for informing curriculum; and annual symposia for presentation of student research, teacher curriculum, and program results. Pillar Two is the in-school curriculum, consisting of an overarching Harbor-Estuary Literacy structure with fully developed modules and lesson plans in grade 7-8 Living Environment-aligned science (marine ecology, water chemistry, ocean engineering) and grade 7-8 Common Core aligned mathematics (linear equations, geometric functions, statistics, and computer programming) developed in advance by UMCES, CLDEO, NYHF, and Harbor School collaboratively. Field trips to waterfront oyster restoration sites for data collection and monitoring are also included. The third pillar, built by UMCES, is the BOP software platform, an online interface enabling students to create their own dashboards, upload, analyze, and compare local environmental data, and practice quantitative research; and enabling teachers and STEM-C professionals to share, critique, and store curriculum resources. Pillar Four is a full-scale estuary exhibit with accompanying educational programs created by local marine science facilities, NYA and TRP. Lastly, the fifth Pillar is the afterschool curriculum and fellowship, an expansion of NYAS's successful STEM mentoring program to 7 GSS afterschool sites using explicit STEM-C curriculum taught by scientists and high school apprentices.

The NSF STEM CCE Partners' extensive pedagogical experience and existing literature indicate that STEM-C teaching and learning is greatly enhanced when students practice authentic science inquiry, field research, and socially beneficial conservation, as opposed to learning exclusively in the classroom/lab without real-world context, physical engagement, or their own data (Altomonte, et.al, 2016). The project expands on previous research-based urban STEM-C enhancements by placing project and restoration-based experiences at the center of an integrated, field-to-classroom curriculum. This model validates that with appropriate application of technical infrastructure, intensive teacher training and holistic curricular scaffolding authentically inquiry-based, socially connected science learning can be main-streamed in the nation's largest urban school system (Hagay, G., & Baram-Tsabari, A., 2015). Significantly, mainstream, large-scale success is achieved by engaging active STEM-C professionals, whose capacities are leveraged through appropriate professional development for in-service science faculty and appropriate use of digital technologies, professional networking and replicable field-based curriculum. The meta-data and evaluative instruments generated during the project will identify those characteristics of the curriculum that are essential to broadening its reach and linking curriculum in other school districts with local problems in restoration and sustainability.

The NSF funded STEM-C Community Enterprise is anticipated to be a fully scalable and transferable model, adaptable to American school districts. Leveraging our evaluative research and open-source technology platform, the program will be readily expanded to the additional 393 public middle schools in New York City at the completion of the project (Browne & Knowles, 2014). Ultimately, it is expected to be expandable to restoration, environmental research and sustainability projects in National and International communities, creating extremely broad impacts on mainstream science pedagogy. The program exclusively engages public schools in neighborhoods with persistent poverty and low socio-economic indicators (Boutte, et al., 2010). The STEM CCE-RS model demonstrates that physically engaged, field-based, authentic scientific research can overcome other systematic inequities to equalize learning for student groups currently under-represented in the STEM-C professions.

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