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Environmental restoration and citizen science: Curriculum and Community Enterprises for Restoration Science



Teaching and learning opportunities for underrepresented students in the New York City Harbour



The world of STEM subjects is your oyster

Engaging students with STEM subjects tends to be quite challenging. However, **The STEM Collaboratory NYC™** at Pace University in the US is providing a practical solution. **Dr Lauren Birney** leads a city-wide collaboration emphasising the benefits of citizen science within restorative ecology to underrepresented students in the New York City Harbor

THE CONCEPT OF citizen science, defined as the engagement with scientific research by members of the public, is providing an opportunity for concerned citizens to actively participate in real, ongoing scientific research efforts within environmental restoration. With the involvement of New York City public schools, students begin to learn about STEM on a practical level while developing skills, such as water quality monitoring data collection and enquiry-based research techniques.

A key benefit of this particular movement is that citizen science has sparked increased awareness regarding the responsibility we all have to engage in scientific discovery. Indeed, the well-documented impact individual actions continue to have on the environment emphasise how we can all play a part in exacting positive change. Thus, encouraging and facilitating widespread participation in environmental restoration through citizen science has the potential to not only benefit the amateur scientists involved and the scientific field within which the research project falls, but also the entire community and surrounding population as a whole. This particular movement focuses upon the ideas surrounding those of smart and connected communities.

RESTORING NOTIONS OF COMMUNITY RESPONSIBILITY

With this in mind, the Billion Oyster Project (BOP), an ecosystem restoration and education project aimed at restoring one billion live oysters to the New York Harbor was launched by Murray Fisher and Peter Malinowski of the New York Harbor Foundation. Over the course of the last 10 years, more than 100,000 schoolchildren have been engaged through restoration-based STEM education programmes and, thus far, have restored over 11 million oysters to the area.

Where oysters once covered more than 220,000 acres of the Hudson River estuary, providing a variety of valuable ecosystem services, the population has since dwindled through overharvesting, dredging and pollution. BOP will reverse these effects, thereby restoring the local marine ecosystem's natural mechanisms for maintaining itself, providing cleaner water and increased biodiversity. Importantly, by acknowledging the benefits of citizen science projects, the team behind the project engages students and the general public, providing them with an increased understanding of and appreciation for the New York Harbor watershed. In planting the seeds of responsibility now, the future success of the New York Harbor can be secured.

ENVIRONMENTAL RESTORATION THROUGH CITIZEN SCIENCE

In acknowledgment of the broader importance of the project, the National Science Foundation (NSF) recently awarded the team responsible a grant of US \$5 million, funding that will enable the project to be extended and expanded. Dr Lauren Birney, Assistant Professor of STEM Education and Director/Founder of The STEM Collaboratory NYC™ – a leading STEM education and engagement scheme at Pace University – is principal investigator for the NSF Curriculum and Community Enterprise for Restoration Science (CCE-RS) project. Results so far have demonstrated several positive developments. “Teachers have displayed a stronger interest in teaching enquiry-based lessons through citizen science and environmental restoration,” explains Birney. “Students continue to exhibit excitement through active participation in the field and have taken ownership of the learning process inside the classroom as well in the field – the field being the New York Harbor. This engagement stimulates an interest in the STEM content areas.”

The STEM CCE-RS model has been developed with three main goals. First, the team aims to increase the quality and effectiveness of STEM-C teaching and learning; second, it endeavours to enhance the knowledge and instructional skills of teachers; and third, its objective is to develop the knowledge of and interest in STEM-C in students. To achieve these targets, the programme created five interrelated components, or ‘pillars’. These are: Teacher Training Curriculum, Student Science Field Research, the Digital Platform, After School and Summer STEM Mentoring, and Community/Museum Restoration-Based Exhibits. Together, these pillars and the CCE-RS Model will enable both students and teachers to get the most out of the programme through continuous support.

STEM EDUCATION FOR UNDERREPRESENTED STUDENTS

The STEM CCE-RS project specifically targets middle-school students in low-income neighbourhoods and students from groups that are underrepresented in STEM fields and education pathways. To engage with this demographic, the Student Science Field Research arm of the project is developing project-based lesson plans across a full school year relating to harbour restoration activities and monitoring the results in the name of scientific research.

Current project activities for students include teachers implementing lesson plans and taking students to field sites to collect water monitoring and observation data – information that will be gathered on a mobile application that has been developed specifically for the project, which will allow students to input data and connect in real time. A process of continued analysis has been emphasised to identify the most effective techniques and strategies for encouraging engagement in the students and,

as such, more experienced teachers mentor those less experienced through a process of sharing and discussing lessons.

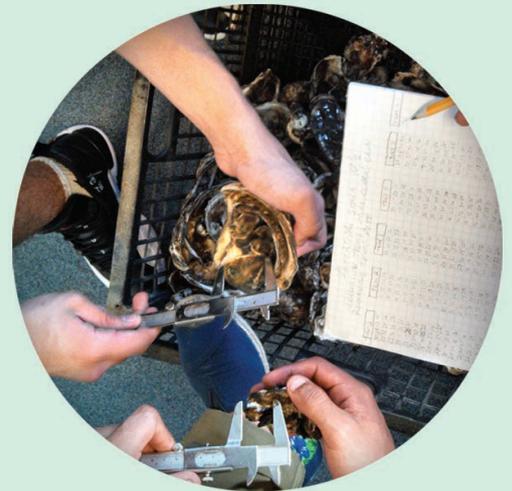
Ultimately, this will fuel a process of continued refinement and revision of the lessons to maximise their effectiveness. However, the analysis does not cease there: "A quasi-experimental, mixed-methods research plan will be used to assess the individual and collective effectiveness of the five project components," explains Birney. "Regression analyses will be used to identify effective programme aspects and assess the individual effectiveness of participation, and social network mapping will be used to further assess the overall 'curriculum plus community' model."

CREATING A SCALABLE AND REPLICABLE MODEL

To ensure that all students have the opportunity to participate in environmental restoration and citizen science, policy changes are needed. This would enable more individuals to have access to environmental science curricula, resources, STEM internship opportunities and projects that allow student participation, creativity and design. This mode of thought is central to the STEM CCE-RS project, with specific focus on giving priority to those students most in need of support, such as underrepresented students, minorities and women. "The project addresses the immediate needs of these students by providing them with the opportunity to be central to the research, design and innovation components of the project," explains Birney. "Student participation in this manner generates ownership in their community, stimulates interest in STEM fields and promotes innovation, creativity and transformation through enquiry and interactive research."

The overarching goal that the model established is fully scalable, transferable and adaptable ensures it can easily be adopted by other school districts outside of New York City – across the US and internationally. Indeed, the intention is to offer the resources to all public schools in New York City across the next decade or so, with a view to expand the model to other geographies, school systems and environmental restoration projects worldwide. We are all citizens of the world and with the success of projects such as STEM CCE-RS, citizen science focused on environmental restoration can demonstrate the enormous positive impacts it has on individuals, STEM-based subjects and the community's environment.

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Five pillars of strength to engage students

THE MISSION OF the Curriculum and Community Enterprise for Restoration Science (CCE-RS) project is to connect teaching and learning to the restoration of the New York Harbor. Ultimately, this will facilitate an enhanced learning experience of STEM subjects for underrepresented students, and present new opportunities and career pathways for those involved in the project.

To achieve these outcomes, an implementation plan has been created that consists of five education-resource pillars. These pillars will work interdependently to support middle school student learning and teacher training, but will also be used in conjunction with five physical project settings – Pace University classrooms for training, the New York City Department of Education, waterfront sites

for field research, Good Shepherd Services/ New York Academy of Science after school programme sites, and marine science research facilities. Each physical setting has been home to several project accomplishments, and many more project activities have been scheduled for the near future.

RESOURCE PILLARS

While the proposed activities of the project will help the team build upon its already considerable achievements, it is crucial that the project is supported by solid foundations. Each pillar works to achieve a specific target but, importantly, they are all interrelated, where each one complements the others in a highly dynamic arrangement. The proposed activities for each pillar are:

PILLAR ONE

Teacher Training Curriculum

Pillar one will recruit and select 20 new teachers to become Cohort 2 teachers, host monthly fellowship and field days, and implement a curriculum map and performance expectations. Importantly, both institutions will host a STEM symposium in order to disseminate the project details, enabling wider understanding in addition to facilitating a report on the project's progress.

Dr Lauren Birney – Co-Principal Investigator, Pace University

Dr Jonathon Hill – Co-Principal Investigator, Pace University

Sam Janis – Project Manager, New York Harbor Foundation

PILLAR TWO

Student Science Field Research

Pillar two involves Cohort 1 teachers who will implement lesson plans designed to maximise successful involvement of underrepresented students, and will actively engage said students by taking them to field sites. There, they will collect water monitoring and observation data on a specially designed mobile application, providing each individual with a sense of responsibility and ownership. Additionally, Cohort 1 teachers will act as mentors to Cohort 2 teachers, where both will share and discuss lessons, identifying what particular aspects are most effective. In so doing, the curriculum will go through a constant process of refinement and revision, ensuring it is as effective as it can be at all times.

Dr Robert Newton – Co-Principal Investigator, Columbia University

Nancy Woods – Co-Principal Investigator, New York Department of Education

IMPROVING STEM EDUCATION IN NEW YORK CITY THROUGH ENVIRONMENTAL RESTORATION AND CITIZEN SCIENCE

OBJECTIVES

To create an authentic STEM curriculum that enables New York City (NYC) middle school students to undertake a local species restoration project and conduct environmental field research, resulting in increased engagement in academics; facilitate enhanced performance in STEM-C disciplines; and create an interest toward learning and environmental restoration in the natural environment of New York Harbor.

KEY COLLABORATORS AND PARTNERS

Pace University • NYC Department of Education • New York Harbor School • Columbia Lamont-Doherty Earth Observatory • University of Maryland Center for Environmental Science • New York Harbor Foundation • New York Aquarium • New York Academy of Sciences • Good Shepherd Services • The River Project (Megan Groome, Jonathan Hill, Samuel Janis, Robert Newton, Nancy Woods, Murray Fisher, Peter Malinowski)

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National Science Foundation (NSF)

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DR LAUREN BIRNEY is Assistant Professor of STEM Education at Pace University and Director of the The STEM Collaboratory NYC™. Birney's focus seeks to address the dramatic needs in STEM Education and facilitate interdisciplinary research through the exchange of ideas among students, faculty and industry stakeholders in STEM disciplines nationally and internationally through smart and connected communities.



PILLAR THREE

Digital Platform

The University of Maryland Center for Environmental Science is an integral aspect of pillar three and will be responsible for maintaining and updating the curriculum portal, digital dashboard and mobile application. The team there will also develop a student dashboard – an online resource that will help each individual chart their own progress and encourage continued engagement. Developing additional capacity for citizen scientists is also part of pillar three's remit, which is of benefit to the scientific community, the students and the individual citizens involved.

Dr William Dennison – Senior Personnel, University of Maryland

PILLAR FOUR

After School and Summer Mentoring

Pillar four will include lessons held at Good Shepherd Services after school programme sites, which will also run during the summer. The out-of-school curriculum lessons will engage students in STEM-C concepts with a focus on invertebrate zoology. Importantly, providing students in low-income neighbourhoods with something to do outside of school hours has genuine potential to influence life outcomes in the long term.

Dr Meghan Groome – Co-Principal Investigator, New York Academy of Sciences

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PILLAR FIVE

Community/Museum Restoration-Based Exhibits

Pillar five involves The River Project, a marine science field station in New York City, and the New York Aquarium. It will be home to interactive exhibits featuring oysters and showcasing the biodiversity of the New York Harbor. These teams will create and maintain all interactive exhibits to facilitate enhanced learning experiences for both students and the general public. In addition to providing important educational resources, The River Project and the New York Aquarium will also host student field trips throughout the course of the programme.

Jon Dohlin – Director, New York Aquarium

Eli Caref – Coordinator, Education Programs



COLLABORATIVE MODEL WITH TREMENDOUS BENEFITS

The Curriculum and Community Enterprise for Restoration Science project is led by Dr Lauren Birney at Pace University, but the success of its implementation has been aided through extensive collaboration. The consortium of partners with a collective expertise in marine and environmental sciences, STEM education and restoration ecology include:

- Pace University
- The New York Harbor Foundation
- The New York City Department of Education
- Columbia University's Lamont-Doherty Earth Observatory
- The New York Academy of Sciences
- University of Maryland's Center for Environmental Science
- Good Shepherd Services
- The New York Aquarium
- The River Project
- SmartStart ECS