Board 118: The STEM Research Academy at Queensborough Community College

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Dr. Dimitrios Kokkinos is an Associate Professor of Physics at Queensborough Community College of CUNY since 2017. He Completed his Electrical Engineering degrees (BE, ME, PhD) at CUNY and undergraduate in Physics in Europe. He worked in industry for AT&T Bell Labs and Verizon Communications for 23 years as a telecommunications engineer specialized in fiber optical system research and development. He is teaching pre-Engineering Physics courses, conducts research in fiber sensors and mentors student research projects.

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Michael Lawrence lectures in Internet Technology & Advanced Manufacturing and Cloud Computing at Queensborough Community College. He received his BS in Astronautical Engineering from the United States Air Force Academy.

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Kimberly Riegel has been an assistant professor at Queensborough since 2015. She completed her Ph.D. at Pennsylvania State University and undergraduate at Vassar College in Poughkeepsie, NY. Her research interests focus on the area of the physics of sound particularly related to noise control using computational and numerical simulations.

Dr. Paul Sideris
Dr. Regina Sullivan , Queensborough Community College
Dr. Paris Svoronos, Queensborough Community College-CUNY
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Dr. Rex Taibu has taught studio physics classes for several years. His teaching experience has shaped his research focus. Currently, Dr. Taibu is actively engaged in

1) promoting scientific inquiry attitudes in students through designing, implementing, and assessing innovative inquiry based physics labs.

2) conducting research regarding the role of language in conceptual understanding.

3) exploring cosmic rays (detection, data collection, and analysis).

Dr. Mangala D Tawde

Nurturing Young Minds: The STEM Research Academy at Queensborough Community College

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Nurturing Young Minds: The STEM Research Academy at Queensborough Community College

Abstract

CUNY Queensborough Community College (QCC) in collaboration with College Now has developed and implemented a research outreach program for high school students as part of the CUNY STEM Research Academy. There are many benefits for high schools students who are involved in research. In addition to the skills they learn as a result of doing original research, students will augment their resume and increase their chances of being accepted to more selective colleges. In the fall, students can also enter science competitions further enhancing their college applications and the opportunity for scholarships. The program consists of two components: a spring semester foundation course where students learn about key scientific principles and how to apply scientific methods, and a hands-on summer research component where students become involved in conducting original research. The spring course is intended to provide the students with the skills they need to undertake science research projects during the summer and includes topics such as data analysis, responsible conduct of research, and the dissemination of scientific data. Fourteen students enrolled in the 2018 research course; most were female (only three males enrolled in the program), and non-minority (only three minorities). During the summer, students were engaged in conducting research under the mentorship of QCC faculty. Research projects included topics such as space weather, acoustic energy propagation, antibiotic resistance of environmental bacteria, and muon flux detection. In a post-experience survey, all students indicated that they had a positive experience and that they would "recommend the program to their friends". All responded that they were interested in pursuing a career in science. In the fall, students were encouraged to submit their research findings to national and regional high school science competitions.

Introduction

There has always been a need for people with expertise at various levels and specialties of science and technology [1],[2]. Despite the demand, there has been a decrease in the proportion of students graduating with non-biological science, engineering and technology

degrees, resulting in a need for qualified personnel to fill essential positions [3]. The numbers are lower for underrepresented minorities (Blacks and Hispanics) and women who account for a disproportionately smaller number of the degrees awarded. For example, Hispanics make up 18.1% of the of the U.S. population [4], but accounted for only 12.8% of degrees awarded in STEM in 2015 [5], while Blacks account for 13.4% of the population but only 8.7% of STEM degrees. Women received 20.1% of the degrees awarded in engineering, 38.7% in the physical sciences, and 18% in computer sciences [5]. This deficiency maybe partly attributed to the limited interest among young people, who do not realize the importance of science and mathematics in their lives and in most jobs [6].

There are many benefits associated with involving high school students in STEM research, including increased academic and interpersonal skills, persistence and graduation rates, and interest in STEM [7][8]. Additionally, high school students engaged in research are more likely to participate in science competitions, giving them additional opportunities to enhance their resume in filing their college application, and receive scholarships and notoriety. Unfortunately, only the more selective high schools tend to have a research mentor program and these programs are targeted to the higher performing students regardless of ethnic diversity.

The STEM Research Academy at QCC is intended to rectify this deficiency by having students, from mostly underrepresented, minority high schools, engage in original research and present their findings at national conferences and competitions. The project consists of two components: a spring research course intended to introduce students to basic skills necessary to conduct successful original research, and a summer research experience where students conduct scientific research under the guidance of Queensborough Community College faculty. The program is part of the City University of New York (CUNY) STEM Research Academy. This paper describes the implementation and results of the pilot year's program.

Recruitment

Recruitment for the program began in October of the preceding semester. Students were recruited from neighboring New York City public high schools through Queensborough's College Now Office. College Now is a partnership between CUNY and the New York City Board of Education that aims to provide students with a college experience while still in high school. College Now at Queensborough works with over 22 high schools, many of which are

largely minority and serve populations that are economically disadvantaged. Project team members visited high schools with underserved student populations and spoke with school administrators to recruit for the program. They also communicated with students and parents who might have any questions about the program.

Students were required to submit an application that required the signatures of a parent and school counselor. Students also had to submit a short essay describing their future academic interests and the reason they wanted to participate in the program. A complete application also included a teacher's recommendation and high school transcript. School grades were secondary in the selection process. Instead, participants were selected based on interest in STEM and their ability to complete the program. The first cohort met in the spring semester of 2018 and consisted of fourteen students. The first cohort of students came from eight high schools, and was comprised of mostly female students - only three males, and Asians - only three being underrepresented minorities).

Spring Research Course

The spring research course was designed to introduce the students to research methods and practices. The course, which consisted of lectures and hands-on activities, met twice a week for fifteen weeks. Each session included both a lecture and lab (hands-on) component, and was three hours long.

The research course introduced students to current research techniques, methods, and approaches through the lens of an astronomy-related project. Students learned about the scientific method, making observations, and drawing unbiased conclusions. Workshops included building different types of telescopes and detecting invisible electromagnetic radiation. Other topics included laboratory safety, research integrity, literature review, analysis and interpretation of data. Students learned to use software to analyze and present data. Initially, the students used Excel spreadsheet, but later learned how to program using Matlab. The students learned about conducting research using human and animal subjects and working with IRBs and IACUCs to ensure their safety and wellbeing. Lastly, students learned to present scientific results in written and oral form.

During the second half of the semester, each of the students conducted a scientific research project under the supervision of the instructor. Students accessed freely available data

online and analyzed it using the tools they learned during the first half of the semester. They came up with their own conclusions and presented their results in a report, a poster, and oral presentation. In the last week of class, the students presented their results to a gathering of parents, teachers, and school administrators.

Summer Research Experience

Upon successful completion of the spring course, students had the opportunity to enroll in a summer research experience with CUNY research faculty in a structured six-week internship. Students were partnered with a mentor and were assigned a project based on their interests and future career goals. Students worked four days a week and received a stipend and food voucher to cover expenses.

The research projects are described below:

1. **Composition of the Solar Wind** - This project analyzed NASA satellite data to study properties of the solar wind. Students correlated solar wind properties with events on the Sun, such as flares and Coronal Mass Ejections (CMEs).
2. **Determination of the Concentration of Antioxidants in Juices and Beverages –** This project had students analyze household beverages for antioxidants using the quantification of gallic acid, in a fashion similar to the one used in the winery business. Students learned chemistry laboratory techniques, including UV-visible spectrophotometry.
3. **Chemistry of Long Island Sound –** Students analyzed historical hydrographic data for Long Island Sound and looked for spatial and temporal trends in the water body's chemistry. In particular, students analyzed the Phosphate (PO_4) and Nitrate (NO_3) concentrations and how these variables affect water quality.
4. **Loss of Signal in the Bend of a Fiber Optic Cable –** This project had students study the loss of signal that occurs when light is transmitted through a bend in a fiber optic cable. Students learned how to use fiber optic tools, splice optical cable, and learn to measure signal strength.
5. **Iron Absorption by Plants and the Role of Heavy Metals in Plants –** Students measured iron concentrations in plant tissue samples collected from various sources

and to assess the extent of iron bonding. Students used spectroscopic techniques such as Mossbauer spectroscopy and X-ray absorption spectroscopy.

6. **Building and Commissioning a Cosmic Ray Muon Detector –** Students built a cosmic ray muon detector. Commissioning the detector included measuring cosmic ray flux and ensuring that its signal detection efficiency met acceptable threshold criteria.
7. **Effect of Single Walled Carbon Nanotubes on Breast Cancer Cell Migration** – In this study, students compared the effect of collagen coated single walled carbon nanotubes with debundled single walled carbon nanotubes on breast cancer cell migration. Students learned techniques involving phase contrast microscopy and fluorescence.
8. **Relationship Between Students' Critical Thinking Skills and Demographics –** In this study students analyzed previously collected data of students' performance on Lawson's test on scientific reasoning and compared the results of the test to several demographic variables.
9. **Creating a Virtual Practice Room: Augmenting Reality with Sound –** In this project, students accurately recreated the sound of a performance space using a computer simulation and compared the derived acoustic parameters to those of the original concert space.
10. **Analyzing Bacteria for Resistance to Antibiotics** – Students collected environmental samples from a variety of locations. The identified species were then identified and tested for resistance to commonly used antibiotics.
11. **Developing a Flexible Laser-Induced Graphene Supercapacitor** – For this project, students used a CO2 laser cutter and engraver and induced graphene unto a Polyimide surface to create capacitors and flexible electronic circuits. Students then studied the properties of the cell, including capacitance and discharge time.

At the end of the summer, students were required to compose a research paper, as well as create a poster and Power Point presentation. In August, students presented their findings at the end-of-summer conference.

Results

To study the effects of the project, the Test of Science-Related Attitudes (TOSRA) [9] was administered at the beginning of the spring course and at the end of the summer. The TOSRA is designed to measure seven science related attitudes for secondary school students. The seven attitudes are shown in Table 1.

Table 1. Name and description of the scales used in TOSRA

Scale	**Description**
Social Implications of Science (S)	Manifestation of favorable attitudes towards science
Normality of Scientists (N)	Manifestation of favorable attitudes towards scientists
Attitude to Science Inquiry (I)	Acceptance of scientific inquiry as a way of thought
Adoption of Scientific Attitudes (A)	Adoption of scientific methods in learning about the world
Enjoyment of Science Lessons (E)	Enjoyment of science learning experiences
Leisure Interest in Science (L)	Development of interest in science and science related activities
Career Interest in Science (C)	Development of interest in pursuing a career in science

The TOSRA was administered by a project team member who was not involved in the either teaching the research methods course or mentoring students during the summer. All the participants initially indicated a favorable attitude towards science (see Figure 1); this did not change significantly as a result of participating in the program. This is not unexpected since these students would have had significant interest in STEM in order to be selected for the program. Overall the students scored above 36.5 on all scales. The adoption of scientific attitudes scale had the lowest mean (36.5), but also increased the most during the program. All scales, except for leisure interest in science, showed an increase between the pre and post-tests. The test-retest coefficient was 0.85.

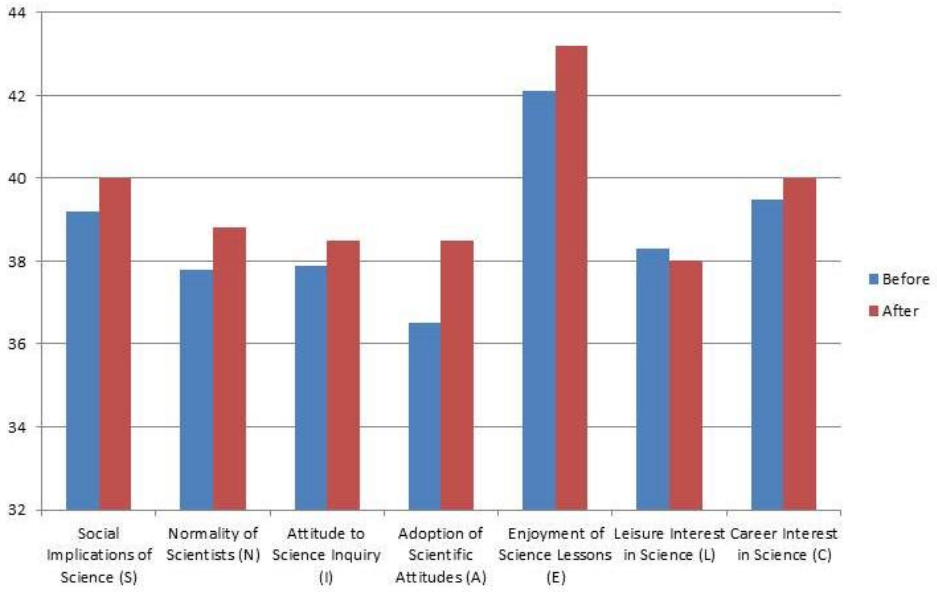

Figure 1. Pre and post mean scores for different student attitudes about science.

Students were also asked their intended career choice and possible major in college. At the beginning of the spring component, all but one of the participants expressed an interest in a STEM field; seven were interested in a health related career and one was not committed to any career. After the summer research experience, several of the students who were interested in medicine said they would consider a career in research. Additionally, the student that was not committed was considering a career in engineering/technology. All students indicated that they had a very positive experience and that they would "recommend the program to their friends".

For the final part of the project, students presented and published their results. Since the end of the summer, students have made presentations at three national/regional conferences (including ASEE), and two more students will present their findings in the spring. Additionally, most of the students have submitted their work to high school science competitions including Regeneron, JSHS (the Junior Mathematics, Science and Humanities Symposium), and NYCSEF (New York City Science and Engineering Fair), the winners of which will qualify for the Intel International Science and Engineering Fair.

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