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Mid-Hudson Young Environmental Scientist Project in Urban Stream Ecology (MH-YES)

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Abstract (word limit - 200)

Broadening participation of diverse groups in Science, Math, Engineering and Technology (STEM) fields is critical to future science success. The goal of the MH-YES project is to engage a diverse group of local high school students in authentic water quality research experiences to build their knowledge, skills, motivation, and confidence for pursuing environmental science. Students did collaborative research into human influences on the ecology of the Fall Kill. Research teams, each comprising three high school students, a mentor scientist, an undergraduate student and a high school science teacher, worked out of two institutions in the Hudson Valley: Cary Institute of Ecosystem Studies and Marist College. Over six weeks, MH-YES teams gained insights into factors that influence two important types of contamination in the Fall Kill: Fecal Indicator Bacteria (FIB) and road salt. The Marist College team evaluated FIB abundance on two types of riparian plants at three sites along the Fall Kill, and the Cary Institute team studied salt retention in different soil types along the Fall Kill and how road salt runoff influences grass seed germination. They also participated in science-identity-supporting activities, such as a panel discussion on diversity in science, a workshop on science communication, and many others.

Three Summary Points of Interest

- High school student teams can design and carry out authentic water quality research studies over a six-week period in the summer.
- Tiered mentoring involving undergraduates and teachers as well as professional scientists helps students gain knowledge, skills, motivation, and confidence in carrying out their own environmental science research, while helping mentors gain confidence and skills in supporting student inquiry and learning.
- Supporting activities within a network of organizations enriches the research experience for the students.

Keywords: student-driven research, high school students, diversity, water quality, Hudson River, Fall Kill, tiered mentoring

Introduction

The mid-Hudson region faces many unique challenges related to its water resources. Originating in the Adirondack Mountains, the Hudson River is subject to run-off from urban and rural settings before it drains into the Atlantic Ocean. The run-off from the mid-Hudson regions' urban areas, industry, and farmlands plays a critical role in the Hudson River Estuary, and identifying and studying these challenges remain critical to protecting this aquatic ecosystem. One challenge of studying water related issues is the engagement of community members with their aquatic environment. Part of this may be due to a lack of connection between community members and the scientists that study the Hudson River. Further, many of the residents of urban centers in this region represent demographics that are poorly represented in STEM fields. There is a national and regional push to engage these communities in science in general, and in water resources in particular. Recently, there have been citizen science initiatives in partnership with secondary school and college students that study bacterial species in the local watershed (Agate et al. 2016). Yet, more research is needed on effective strategies for engaging these communities (de Lacalle and Petruso 2012). We address both the critical need for better understanding of urban streams and the need for effective community engagement strategies through the MH-YES project.

The impact of involving students in supporting and challenging research experiences is well known (Thiry et al. 2016), though the impact on high school students is not as well documented. Zhe et al. (2010) describe a high school STEM bridge program incorporating the best approach from the literature for increasing interest and self-confidence in STEM that "was one that relied upon inclusive, inquiry-based science, emphasized problem-based learning, and incorporated visual demonstration". They reported that the program was very successful at encouraging students to attend college with 86% of those intending to continue to college choosing STEM majors. The near-peer mentoring approach describes a situation where an undergraduate student involved in research project mentors a middle or high school student. Tenenbaum et al. (2014) studied this approach for a science education summer research internship program. They found advantages for both groups. High school students had an increased interest and engagement in the STEM disciplines.

The MH-YES project idea was developed as a direct result of discussions of best practices supported by an NSF INCLUDES design and implementation grant awarded to Columbia University. The Secondary School Field Research Program (SSFRP) run by the Lamont Doherty Earth Observatory, in which high school students spend a summer working on research projects with Lamont scientists, highlights the value of near-peer mentoring and involving high school students in real scientific research experiences and has documented success in attracting underrepresented groups into STEM fields (Margie Turrin, pers. comm.). This project incorporates these best practices while involving students in research experiences that increase understanding of Hudson Valley aquatic ecology and chemistry.

Results & Discussion

We observed many benefits from the 2018 MH-YES project. On the water quality research level, we gained insights into the factors that influence two important types of contamination in the Fall Kill that were studied by the MH-YES teams: Fecal Indicator Bacteria (FIB) and road salt. The Marist College team evaluated FIB abundance on two types of riparian plants at three sites along the Fall Kill, and found that FIB was present on both plant types, and that abundance did not differ by plant type or by site, and was not correlated with FIB abundance in the water at the site. The Cary Institute team studied salt retention in different soil types along the Fall Kill and how road salt runoff influences grass seed germination. They found that soil types did not differ in their salt retention rates, and that grass seeds are sensitive to salt and do not germinate when watered with a solution of $\frac{1}{4}$ or higher of roadway runoff salt concentrations.

We achieved our goal of having more than half of the high school participants come from traditionally-underrepresented groups: four of the six high school students met this criteria. In terms of student knowledge, skills, motivation, and confidence, results from 2018 were uniformly positive. In surveys and interviews, all students reported that the project gave them an opportunity to experience "real research", which provided agency to continue in STEM. In retrospective pre-post questions, students reported that the program increased their knowledge, confidence, intention

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to study science, and understanding of what scientific research is (Figure 1). Students also reported that the MH-YES Program increased their awareness of possible jobs in STEM.

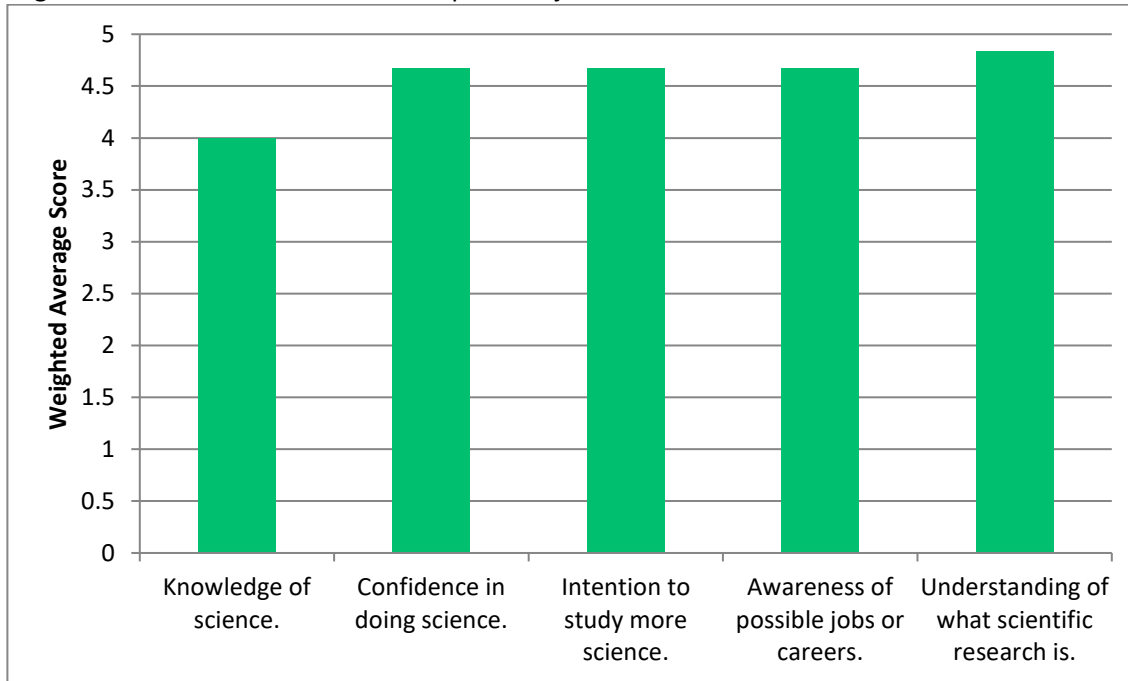


Figure 1. Students' self-reported gains due to the MH-YES Program in response to the question: "Participating in the summer research program increased my. . ." Possible scores ranged from 1 (not at all) to 5 (a lot).

Students also reported that the program influenced their communication and teamwork skills (Figure 2). They believe they are more able to tell others what they've learned, work as part of a team or group, and think critically to solve a problem.

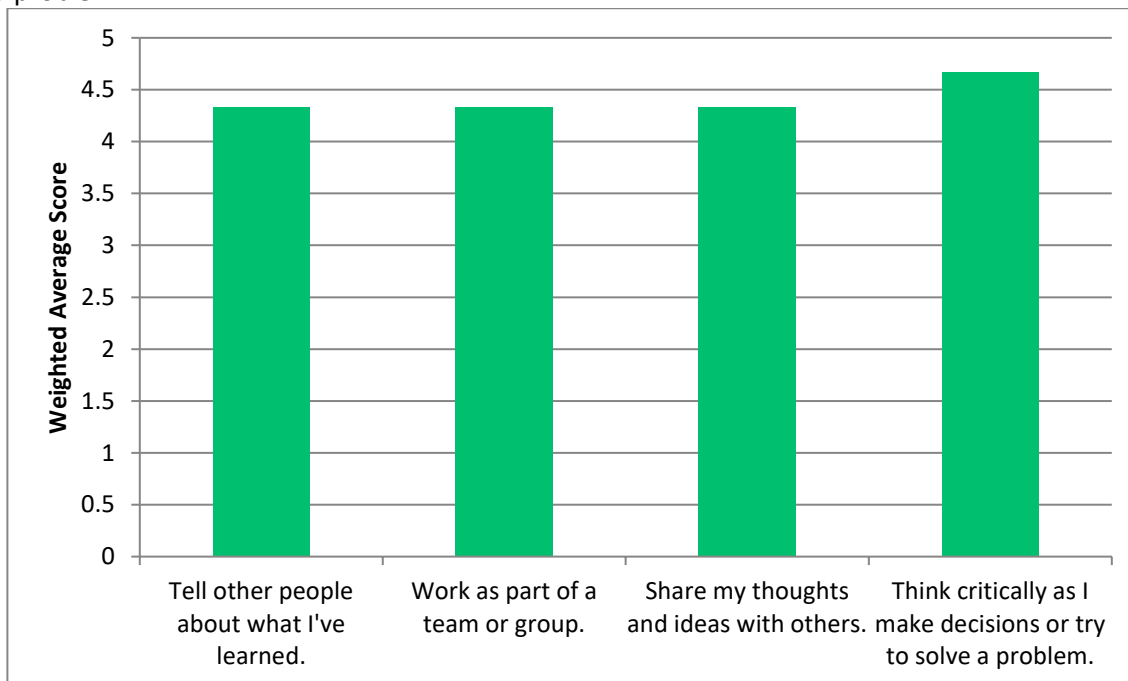


Figure 2. Students' self-reported improvement in response to the question: "Participating in the summer research program has improved my ability to. . ." Possible scores ranged from 1 (not at all) to 5 (a lot).

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Methods

MH-YES teams worked together daily on weekdays from July 2nd to August 10th, 2018 in order to accomplish their research and community engagement goals. All participants worked together to learn the basics of aquatic ecology and develop their research proposals in the first week, and then teams split up to carry out their research in the remaining five weeks, which culminated in a presentation of their research to peers and the public at a research symposium on August 10th, 2018. During these five weeks, students on the Marist team collected water samples and bacterial samples from plants in the Fall Kill, and analyzed them for FIB concentrations using the IDEXX system. The Cary team collected soil samples and set up percolation columns to test salt retention of different soil types, as well as growing grass seeds under differing salt treatments in a greenhouse. In addition, the two teams met together weekly on Fridays to discuss what they had accomplished in that week, make a plan for the upcoming week, and work through any roadblocks that they had encountered.

Students participated in enrichment activities on a weekly basis, which included visiting other high school students involved in environmental research, attending a panel on diversity in science, and learning about other aspects of aquatic ecology. They also planned their participation in the community outreach event, which involved recruiting attendees and educating people about the Fall Kill at a cleanup event on July 21st, 2018 at Malcolm X Park in Poughkeepsie.

Outreach Comments

There were two main outreach events associated with the MH-YES project (highlighted in bold), and a number of related events listed below, at which MH-YES students presented their research findings.

- **Malcolm X Park Community Clean Up (July 21st, 2018)**
- **MH-YES Final Symposium (August 10th, 2018)**
- Lamont Doherty Earth Observatory SSFRP Final Poster Symposium (August 15th, 2018)
- School Board Meeting, Arlington Central School District (October 9th, 2018)
- Lamont Doherty Earth Observatory Open House (October 13th, 2018)

We worked with a number of government and community organizations to coordinate aspects of this program in addition to Marist College and Cary Institute. These include:

- Lamont Doherty Earth Observatory at Columbia University
- Scenic Hudson
- Hudson Valley ReEntry Network
- Norrie Point Environmental Center
- Hudson River Sloop Clearwater
- Poughkeepsie Farm Project
- Hudson River Park
- The River Project

Student Training

High school students trained: 6

Undergraduates trained: 2

Teachers trained: 2

Students reached through teachers: ~250

Publications/Presentations

This project resulted in 3 presentations of the two student research posters: at the MH-YES Final Symposium, the Lamont Doherty Earth Observatory Poster Symposium, and the Lamont Doherty Earth Observatory Open House. In

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addition, students from both teams took the initiative and wrote one paper per team about their results, which they submitted to journals of high school research (citations given below).

Huang, J., Hawkinson, E., Rashid, N. (2018). Exploring Soils' Retention of Salt and the Effect of Road Salt on Plant Height. Poster Presentation, MH-YES Final Symposium, August 10th, 2018.

Weir, J., Akpojetavwo, A., Rosa, C., (2018). Fecal Indicator Bacteria On Plants In The Fall Kill Creek. Poster Presentation, MH-YES Final Symposium, August 10th, 2018.

Huang, J., Hawkinson, E., Rashid, N. (2018). Exploring Soils' Retention of Salt and the Effect of Road Salt on Plant Height. National High School Journal of Science (in review).

Weir, J., Akpojetavwo, A., Rosa, C., (2019). Fecal Indicator Bacteria On Plants In The Fall Kill Creek. International Journal of High School Research (in review).

Additional final reports related to water resource research are available at <http://wri.cals.cornell.edu/news/research-reports>

References

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de Lacalle, S. and Petruso, A. "The Value of Partnerships in Science Education: A Win-Win Situation." (2012) *Journal of Undergraduate Neuroscience Education* 11.1: A97.

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Thiry, H. Laursen, S. and Hunter, A. (2016) What Experiences Help Students Become Scientists? A Comparative Study of Research and other Sources of Personal and Professional Gains for STEM Undergraduates. *The Journal of Higher Education*, **82:4**, 357-388.

Zhe, J.; Doverspike, D.; Zhao, J.; Lam, P.; and Menzemer, C. "High School Bridge Program: A Multidisciplinary STEM Research Program" (2010) *Mechanical Engineering Faculty Research*, 954.

Appendices (if needed)

Cary Institute Team Poster: [https://drive.google.com/file/d/1Ai-
ipRGbMXbywPkIfWK1a3mah1NwXist/view?usp=sharing](https://drive.google.com/file/d/1Ai-
ipRGbMXbywPkIfWK1a3mah1NwXist/view?usp=sharing)

Marist College Team Poster: [https://drive.google.com/file/d/1AiHYLEok786LqF-3--uuKD6dpCTq1-
3N/view?usp=sharing](https://drive.google.com/file/d/1AiHYLEok786LqF-3--uuKD6dpCTq1-
3N/view?usp=sharing)