



NEW YORK STATE WATER RESOURCES INSTITUTE

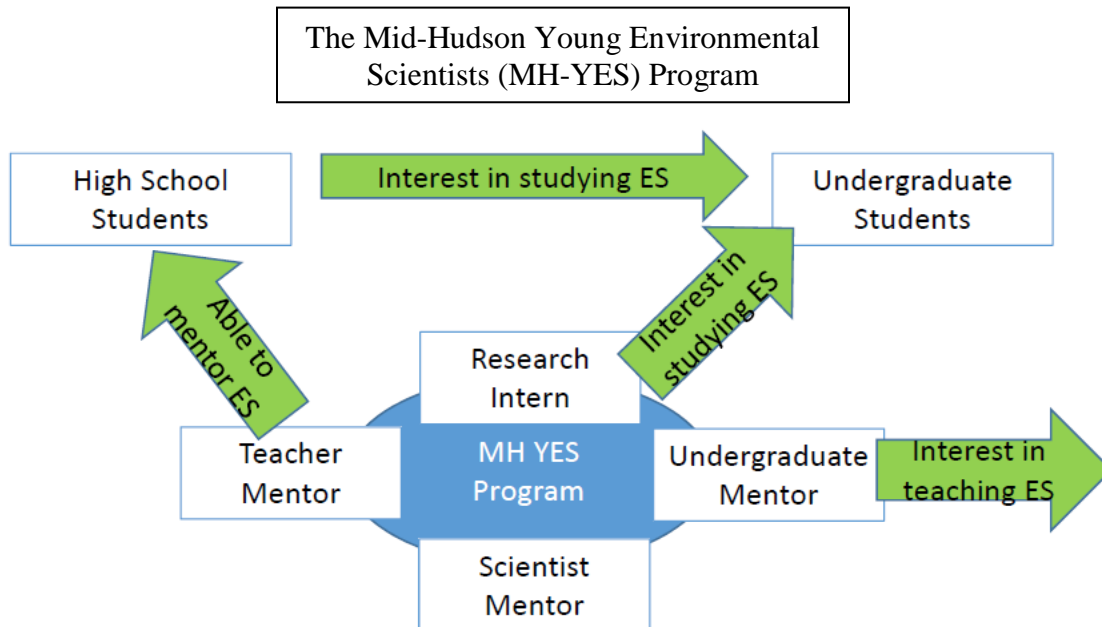
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Mid-Hudson Young Environmental Scientist Project in Urban Stream Ecology (MH-YES)

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Abstract

Broadening participation of diverse groups in Science, Math, Engineering and Technology (STEM) fields is critical to future science success. The MH-YES project aims to raise awareness of options to study and work in the environmental sciences among diverse groups of students. Teams of high school and college students work with teachers and scientists to conduct authentic water quality research to build their knowledge, skills, motivation, and confidence for pursuing

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environmental science. In 2019, the Marist-based MH-YES team compared rural and urban streams and the factors that influence harmful algal blooms. The Cary-based team studied the effects of dams on the ecology of the Fall Kill Creek. At the end of the six week program, teams presented their results in posters at the MH-YES Final Symposium and each wrote a final report that will be used by their mentors in their future research. Students and teachers participated in enrichment activities that supported their skills, interest and identity as scientists. They also joined students in partner programs in New York City and the lower Hudson Valley to share their experiences, attend a panel discussion on diversity in science, a workshop on science communication, and a forum on opportunities in translational ecology.

Three Summary Points of Interest

- **High school students working in teams with strong mentors can design and carry out authentic water quality research studies over a six-week period in the summer and gain knowledge, skills, motivation, and confidence in pursuing environmental science in the future.**
- **Undergraduate students and high school teachers serving as mentors to high school students gain confidence, motivation and skills in supporting student inquiry and learning.**
- **Supporting activities within a network of organizations enriches the experience of students and teachers.**

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 inputs 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 to investigate bacterial species in a 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 in which an undergraduate student involved in a 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, and undergraduate mentors experienced personal, professional, and educational growth.

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 to STEM fields (Margie Turrin, pers. comm.). The MH-YES project incorporates these best practices while involving students in research experiences that increase understanding of aquatic ecology and chemistry in the mid-Hudson region.

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Methods

MH-YES is a tiered mentoring program where two teams of 4 high school students each work with an undergraduate student, a local high school teacher and a mentor scientist to design and carry out a research project in stream ecology. In 2019, as in 2018, one team was based at Cary Institute, working with Dr. Stuart Findlay, while the other team was based at Marist College, working with Dr. Zion Klos. High school students were recruited in winter of 2019, with 29 students completing applications by the 1 April 2019 deadline. Eight students were selected after interviews, reference checks and consultation with the mentor scientists. Teachers were recruited from local contacts. Final selection of teachers from the small pool of applicants was done after interviews with project leaders. Finally, the undergraduate student for the Cary team was drawn from a pool of nearly 300 applicants to the Cary Research Experiences for Undergraduates (REU) program, while the student for the Marist team was drawn from Dr. Klos's pool of interested environmental science majors. A meeting was held in early June with teachers, undergraduates and scientists to develop a shared vision for the program, develop mentoring strategies and plan program activities. The summer program ran from July 1 through August 9, with teams working 32 hours/week on the project. 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 9, 2019. At that time, the two student teams gave oral presentations about their summer experience, and produced formal scientific posters that presented their research.

An overview of the 2019 program is shown in Table 1. Most of the program was spent on the team research projects, with supplemental activities to develop students' research skills, scientific background, and awareness of options to study and work in the environmental sciences, and to help connect them to resources and opportunities in their community. MH-YES students interacted with other high school students involved in environmental research, attended a panel on diversity in science, participated in workshops, seminars and the Cary REU Forum on Opportunities in Translational Ecology and went on field trips to Hudson River Park and the Sloop Clearwater. They also planned participation in a community outreach event that was cancelled due to excessive heat. These enrichment activities took place 2-3 times each week. The two MH-YES 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. Post-program surveys indicate that students found most of the MH-YES program activities to be very or extremely valuable (Table 2).

The MH-YES undergraduate students worked closely with their team, serving as near-peer mentors and role models, helping with science cognition, and trouble-shooting during both field and lab work. They were instrumental in helping the high school students analyze their results and produce their final presentations and posters. In addition, the undergraduates carried out their own research projects to which the high school students contributed some data collection in the field. The MH-YES teachers provided on-going support to the high school students, providing a type of mentoring and guidance that teachers are uniquely able to give. In addition, the teachers each developed an instructional plan to incorporate the skills acquired during their summer Research Experience for Teachers (RET) fellowship into their science curricula. Periodic meetings with Dr. Berkowitz, and with an RET follow working with Cary educators in Baltimore, supported the teachers in this effort.

Table 1. 2019 MH-YES program activities

Week	Cutting Edge Independent Research	Linking to Policy and Management	Linking to the Public	Linking to Education	Reflective Practice and Training
Pre-program				RET and mentor training: Effective mentoring strategies for	

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				diverse students	
1	<p>Aquatic Ecology Boot Camp Form teams and develop research questions</p> <p>Presentations of students' research plans</p>	Invasive species, pollution, destruction of Hudson River's wetlands - what's being done, what needs to be done	<p>Meet with community engagement group - Scenic Hudson</p> <p>Begin planning community event</p>		<p>Field Exercise – Questions & Hypotheses</p> <p>Safety training</p> <p>Reflective journaling</p>
Forum on Translational Ecology					
2	<p>Research proposals due</p> <p>Field and lab research</p>	Microplastics study at Norrie Point	Communications Workshop	Seining, microplastics study, and water quality testing at Norrie Point	<p>Responsible conduct of research training</p> <p>Reflective journaling</p>
3	Field and lab research		Translational Ecology put to work: Elevator Speeches	Sail on the Sloop Clearwater	Reflective journaling
4	Field and lab research			Teaching students about water quality at Cary Camp	Reflective journaling
5	Field and lab research, data analysis	Diversity in Science Panel	Visit Hudson River Park	REU Symposium	<p>Diversity in Science Panel</p> <p>Reflective journaling</p>
6	<p>Data analysis</p> <p>Final MH-YES Symposium</p>	Recommendations from student projects	Final MH-YES Symposium		Reflective journaling

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Table 2. Number of students reporting different levels of value of the supplemental, enrichment activities in the 2019 MH-YES program, from the post-program survey.

Program Activity	Not at all valuable	Minimally valuable	Somewhat valuable	Very valuable	Extremely valuable	Mean
STEM Diversity Panel in NYC	0	0	0	0	8	5.0
Practice Public Speaking	0	0	0	1	7	4.9
Aquatic Ecology Boot Camp	0	0	1	2	5	4.5
Visiting Norrie Point (DEC)	0	0	0	5	3	4.4
Cary Translation Ecology Forum	0	0	2	1	5	4.4
Mock Interviews with Mentors	0	0	2	1	5	4.4
Communicating Science Workshop	0	0	1	4	3	4.3
Weekly check-in meetings	0	1	1	2	4	4.1
Statistics Workshop with Scientist	0	1	2	2	3	3.9
Sailing on the Clearwater	0	1	4	1	2	3.5
Visiting Cary Camp	1	2	0	3	2	3.4

Results & Discussion

We observed many benefits from the 2019 MH-YES project. Each research project produced results that will be useful for the mentor scientists in their ongoing research. The Marist-based MH-YES team compared rural and urban streams and the factors that might influence harmful algal blooms. They found water temperatures and conductivity higher in the urban stream, but nitrate, orthophosphate and pH higher in the rural stream. These results suggest that runoff from roads and other surfaces could be responsible for raising the temperature and conductivity (due to road salt) of the urban stream, while agricultural fertilizer use could be raising the nutrient levels in the rural stream. The Cary-based team studied the effects of dams on the ecology of the Fall Kill Creek. They discovered that water temperatures were consistently higher in outlet streams compared to inlet streams for each of three impoundments studied. At the end of the six week program, teams presented their results as posters at the MH-YES Final Symposium, and each team wrote a final report that will be used by their mentors in their future research.

A majority of the 2019 cohort of high school students are from groups traditionally underrepresented in STEM: four are Hispanic and one is African American; and one student is transgender. One of the two college students is Hispanic, and both high school instructors teach at schools with significant minority populations. Thus, we achieved our goal of engaging and, through the teachers reaching, a diverse pool of students in environmental science.

We used pre- and post-program surveys and interviews of all student participants to help gauge the influence of participation. Figure 1 presents self-reported gains for the 8 high school students in different aspects of science research from the post-program surveys. All students reported maximum gain in understanding what researchers do, with large gains also reported for their knowledge and confidence in conducting research and awareness of STEM careers.

High school students reported large gains in their skills and attitudes about science and the environment (Figure 2), especially in their ability to accept responsibility, their science skills and their desire to take care of the environment. Also impressive were the gains they reported in the personal and social aspects of doing science, including teamwork (Figure 3). A majority of the students reported “a lot” of gain for all items in this section of the post-program survey, with the highest score given to the item regarding their ability to think critically. This is a very positive outcome.

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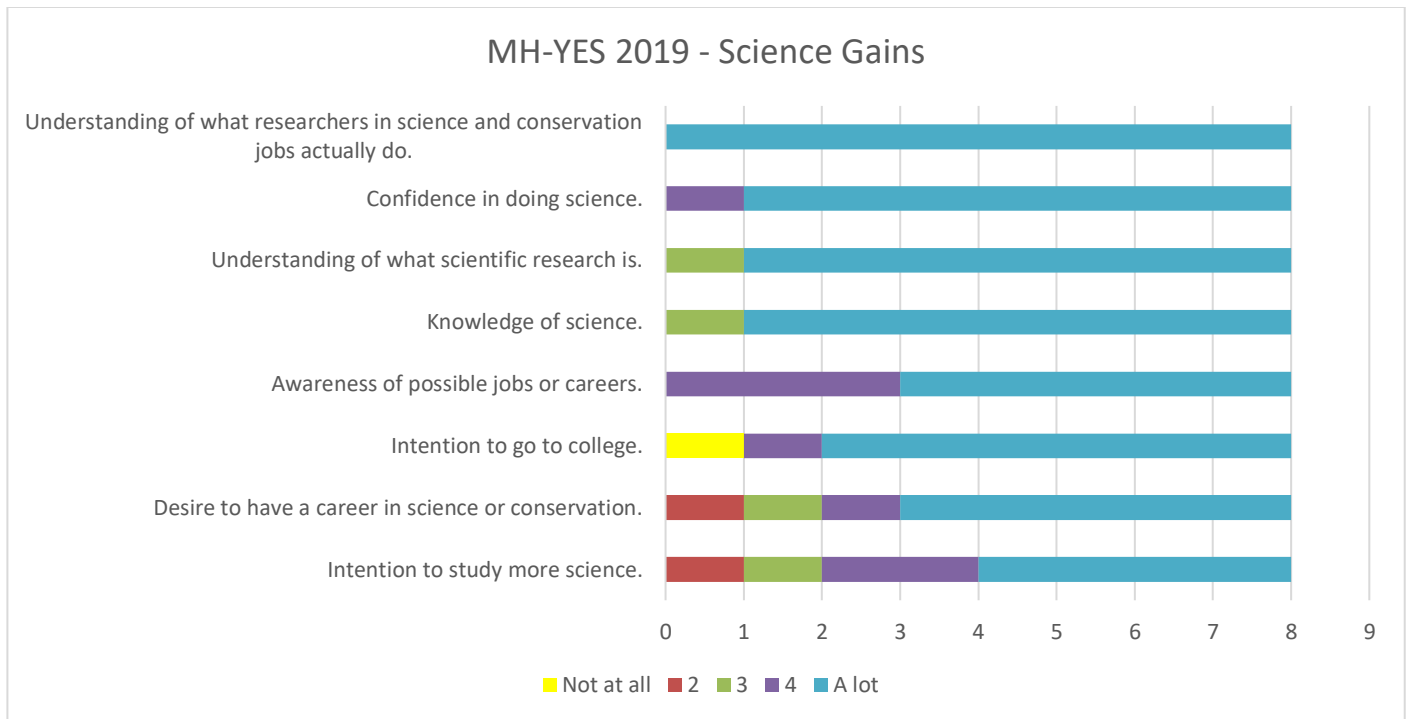


Figure 1. Number of students reporting gains for different science items in post-program survey. The question asked, “Participating in the summer research program increased my ...” with score choices ranging from 1 = not at all to 5 = a lot. Items are sorted from those receiving the high scores overall at the top, to lower scores at the bottom.

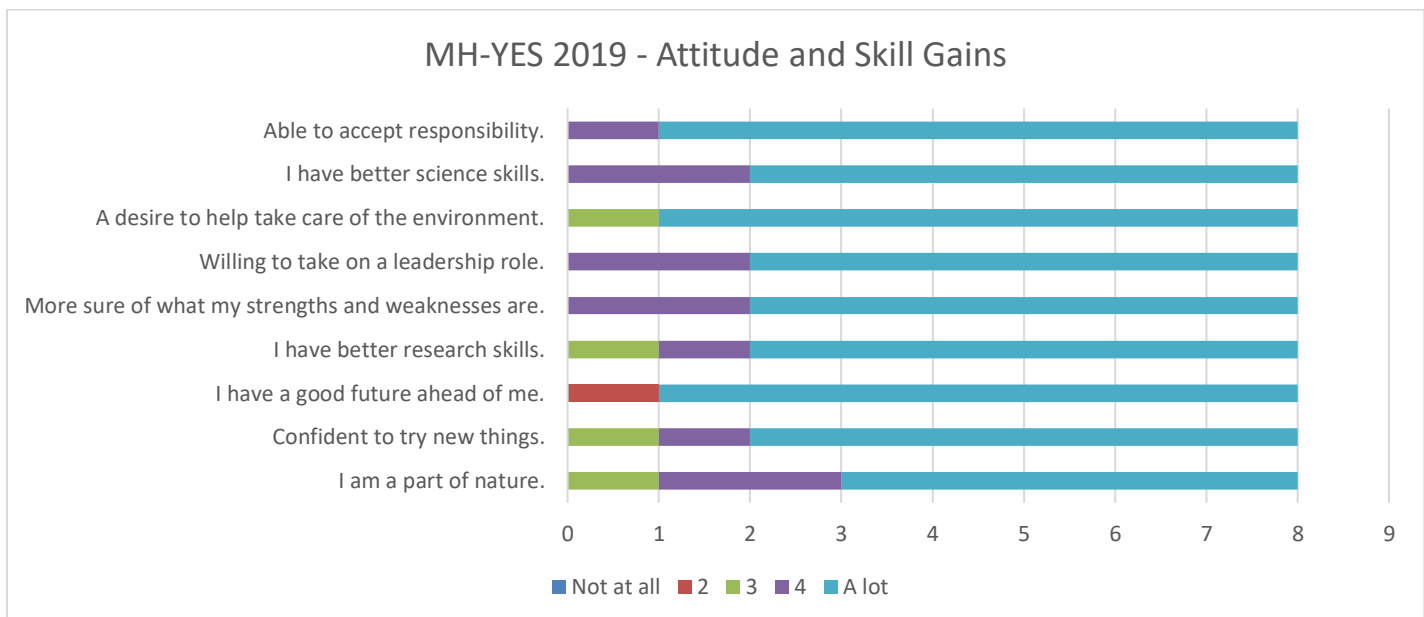


Figure 2. The number of students reporting gains for different attitudes and skills in post-program survey. The question asked, “Participating in the summer research program has helped me feel ...” with score choices ranging from 1 = not at all to 5 = a lot. Items are sorted from those receiving the high scores overall at the top, to lower scores at the bottom.

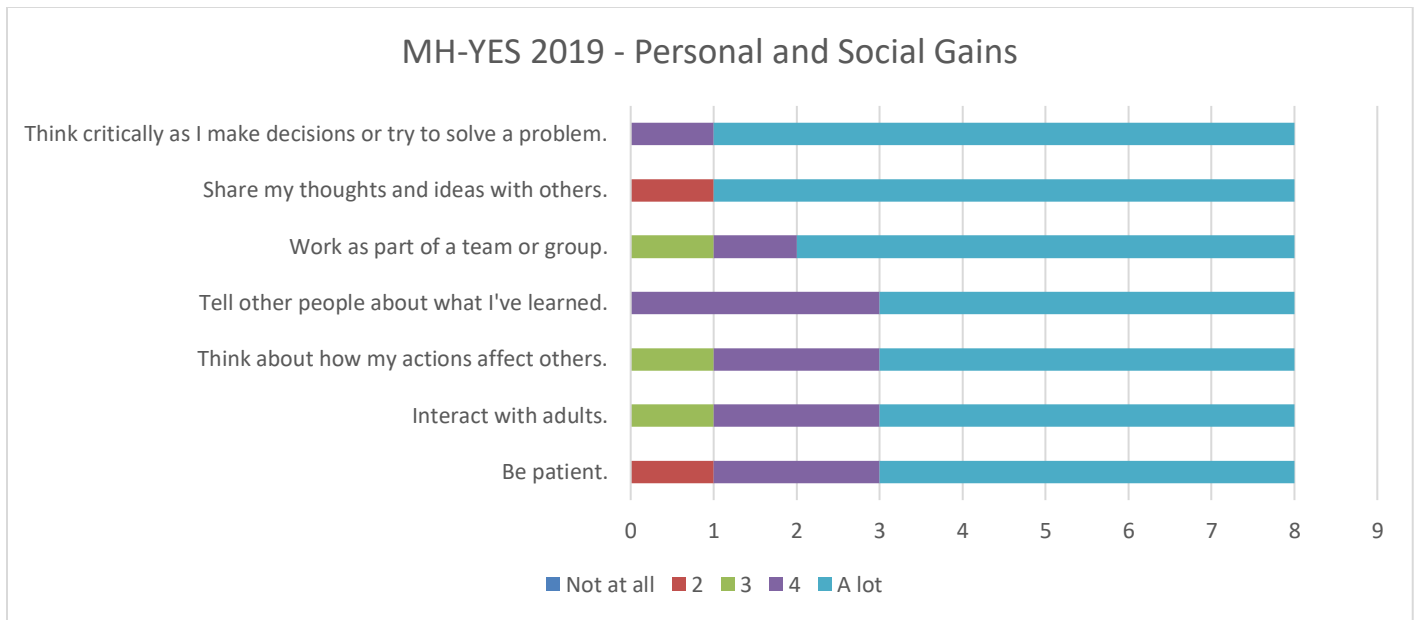


Figure 3. The number of students reporting gains for different personal and social aspects of doing science in post-program survey. The question asked, “Participating in the summer research program has improved my ability to ...” with score choices ranging from 1 = not at all to 5 = a lot. Items are sorted from those receiving the high scores overall at the top, to lower scores at the bottom

High school students left the program feeling most confident about doing fieldwork, asking questions and formulating hypotheses, conducting a research project and working as part of a team (Figure 4). Students were least confident in their ability to analyze data, which is a very similar outcome to what we find with undergraduates. More in-depth insights into the impacts of participation on the high school students is available in the report of our outside evaluator, Cornelia Harris, based on interviews before and after the summer program.

Undergraduate students were successful in completing their individual research projects; the Cary student within a few weeks of the end of the summer program producing a paper that will appear on-line as a Cary Institute Undergraduate Ecology Research Report, and the Marist student concluding research in the semester following the summer program. One of the students completed the post-program survey and reported very positive results of her mentoring experience. For example, she commented that the program “... helped me see what my teaching style is and also how to keep track of my mentees and what to better adjust.” She rated herself a “4” on a 1 to 5 scale in confidence as a mentor, stating, “I felt I did a pretty good job at mentoring the students in the ways I was capable but I also recognize that there were some things I could have helped more to guide them and prep them.” When asked “How likely are you to pursue professional activities involving research mentoring in the future,” she replied, “moderately,” and explained, “I would like to teach students in the future and help guide them in their journeys.” The experience cemented this students’ identity as a scientist, and advanced her interest and confidence in education.

Teachers in the MH-YES program also reported very positive outcomes from their participation. Indeed, both have applied to participate again based on their experience in 2019. Each produced an instructional unit based on their summer experience that she is pilot testing with her students during the current school year. In post-program surveys, they rated most of the program activities as extremely valuable, though the sail on the Clearwater, visiting Cary Camp and Resume Building (all mostly geared towards the high school students) were rated less valuable than the other activities. They reported “a lot” of learning about most aspects of aquatic ecology, especially the topics that were the focus of the team research projects, and designing ecology field studies. It was clear from the post-program debriefing session that both teachers cherished the opportunity to refresh and deepen their research skills, especially in addressing important questions about environmental problems. Finally, both teachers indicated that as a result of participating in MH-YES, they would regularly engage their students in inquiry-based learning where students uncover their own questions, and occasionally do three other teaching practices: 1) design ecology research with students, 2) help students work with data, and 3) help students engage the public with ecology.

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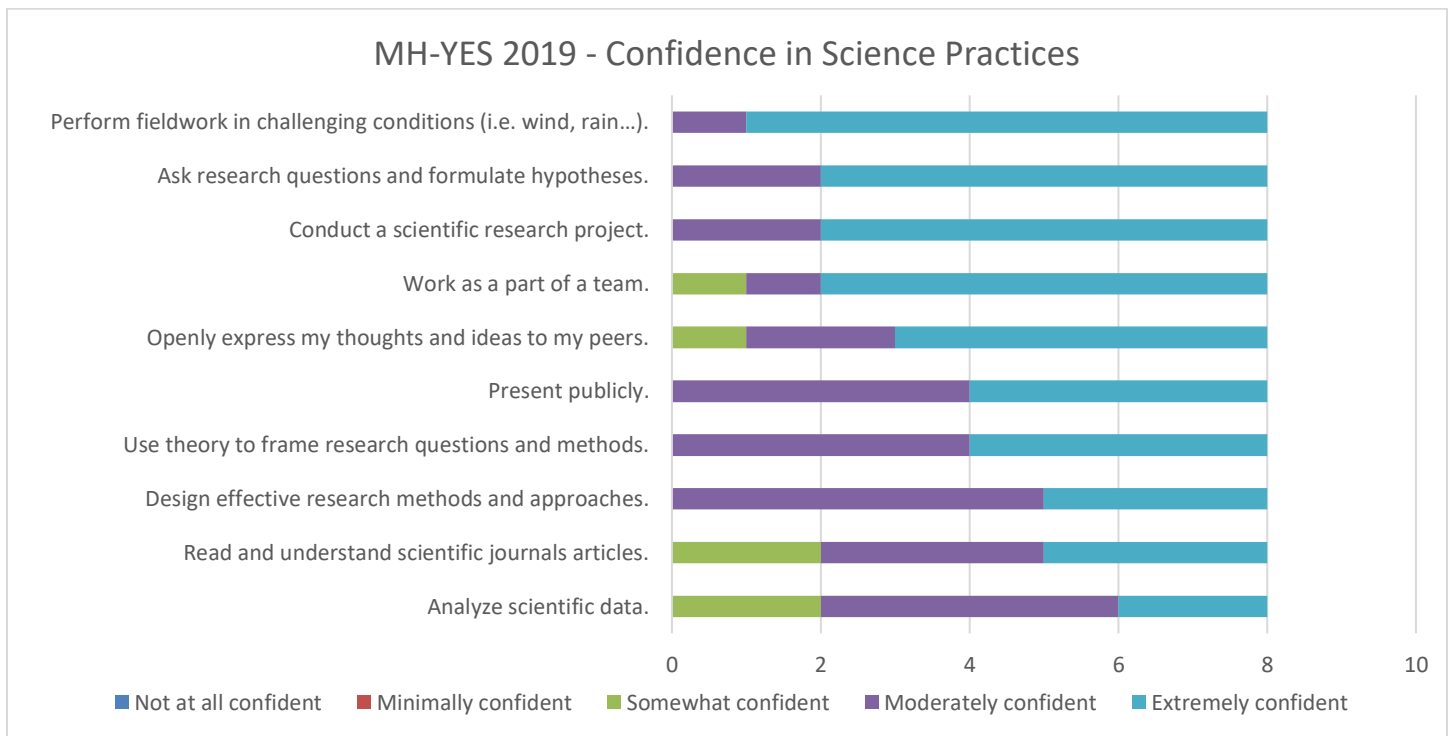


Figure 4. The number of students reporting rating their confidence in their ability to do a number of different science practices. The question asked, "Rate your confidence in doing the following." Score choices ranged from 1 = not at all confident to 5 = extremely confident. Items are sorted from those receiving the high scores overall at the top, to lower scores at the bottom

Outreach Comments

Two community outreach events were planned for the 2019 MH-YES project (highlighted in bold), and a related event also took place (listed below).

- **Waryas Park Community Event (July, 2019)** – cancelled due to excessive heat
- **MH-YES Final Symposium (August 9th, 2019)**
- Lamont Doherty Earth Observatory SSFRP Final Poster Symposium (August, 2019)

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
- Hudson River Park
- The River Project

Student Training

High school students trained: 8

Undergraduates trained: 2

Teachers trained: 2

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Students reached through teachers: ~250

Publications/Presentations

This project resulted in 2 presentations of the two student research posters: at the MH-YES Final Symposium and the Lamont Doherty Earth Observatory Poster Symposium. Student posters were:

LaRosa, K., H. Qureshi, E. Rojas and M. Tawil. 2019. Battle of the Streams: Water impoundments emptying into urban and rural riparian zones and the influence on water quality and on the growth of potential cyano HABs before and after rain events. Poster Presentation, MH-YES Final Symposium, Cary Institute, Millbrook, NY. August 9, 2019.

Basilone, A., G. Lalli, G. Ng and D. Tulloch. 2019. Effects of impoundments on water quality in the Upper Fall Kill Creek using multiple independent variables. Poster Presentation, MH-YES Final Symposium, Cary Institute, Millbrook, NY. August 9, 2019.

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