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Pre-College Science and Engineering for Inner-City Middle School Students

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Pre-College Science and Engineering for Inner-City Middle School Students (Work in Progress)

Significant effort has gone toward improving diversity in the science, technology, engineering and math (STEM) fields over the last several years. Nationally, some positive trends have been observed, but a significant race/ethnicity gap still remains. While engineering bachelor's degrees grew by 6% from 2013 to 2014, degrees to Hispanic students increased by only 0.8% and those awarded to African American students *decreased* by 0.8%[1]. Moreover, while African American and Latino workers represent 29% of the general workforce, they represent only 15% of the computing workforce, and 12% of the engineering workforce[2]. Not only does this lack of diversity in the STEM workforce place African American and Hispanics/Latinos(as) at a disadvantage, it also gives way to a very homogeneous environment, which could be disadvantageous for those who take part in it.

Research suggests that a diverse workforce provides economic benefits since heterogeneous groupings bring different perspectives to problems which could yield creative, effective, and widely applicable solutions[3,4]. A heterogeneous workforce could also provide new insights into the needs of previously underserved populations[5], which can ultimately help increase diversity even further. Therefore, it is imperative that the educational participation of underrepresented minorities in STEM fields is increased by implementing appropriate strategies that can specifically target these groups. According to research findings, these strategies are more likely to succeed when teacher professional development and mentorship opportunities are included[6,7,8]. For this reason, we have launched a new pre-college science and engineering program for inner-city middle school students that brings college and pre-college students together, and also provides professional development to the teachers involved in the program.

Program Background and Overview

The College of Engineering and the College of Education at the University of Illinois at Urbana-Champaign (UIUC) have partnered with the Chicago Pre-College Science and Engineering Program (ChiS&E) nonprofit to develop a diverse K-12 STEM pipeline. ChiS&E has previously established a K-5 STEM program targeting students in underserved communities that currently serves about 250 students at no cost to the participants. This new partnership seeks to build on the existing program to fully develop a K-12 pipeline featuring sustained engagement with the students and their families. The first stage of this effort was a pilot program offered to 6th and 7th grade students from the Chicago Public School (CPS) district in the fall 2015. The middle school program was designed with sustainability in mind, and utilizes experts from engineering, science and education to partner with CPS teachers to implement a hands-on, active learning curriculum. The pilot program included a Professional Development Day for the five middle school and high school math and science teachers involved, four half-day Saturday sessions, 50 inner-city, CPS 6th and 7th grade students (99% African American and Hispanic/Latino), and over 30 undergraduate students that served as mentors. The first three Saturday sessions were held at the College of Engineering at the University of Illinois at Chicago

(UIC) campus, and the fourth and last Saturday session involved a fieldtrip to the UIUC campus, where students and their parents participated in an engineering competition, went on engineering campus tours, and experienced campus life for a day. For assessment purposes, students were given a pre-test at the beginning of the first Saturday, and a feedback survey at the end of the fourth Saturday. The post-test will be administered at the end of the academic year, when the students complete a year in the program.

Program Curriculum & Teacher Professional Development

The program curriculum used in the Saturday sessions was designed by math and science education experts from the College of Education at UIUC, and was titled "*Using Mathematics to Explain the Physical World*". The curriculum allowed the use of mathematical models and real-life situations to delve deep into different scientific and mathematical concepts, such as volume, density, and linear, quadratic, and exponential models. Prior to the start of the Saturday program, the curriculum developers led a Professional Development Day with the five middle school and high school math and science teachers from CPS that are involved in the program. During the workshop, teachers became familiar with the curriculum and also learned about collaborative learning and best practices for project-based lessons. The curriculum developers were able to attend several of the Saturday lessons and provided constructive feedback and recommendations to the teachers enacting the lessons. This method of peer review teaching has shown to be an effective form of teaching development, as it can enhance the quality of teaching and learning, provide feedback that affirms good practice, uncover areas for possible improvement, and can enhance academic staff members' commitment to and insight into teaching[9, 10, 11].

Students working on the density activity.

To obtain feedback from the students regarding the lessons, we asked them to rate the overall quality of the lessons. By the end of the fourth Saturday session, the 45 students in attendance rated their lessons on a scale of 1-5, one being the worst and five being the best. As figure 1 shows, 49% of the students rated the lessons with a perfect score of five, and 42% with a score of four. These results indicate that students were pleased with the curriculum and enjoyed the activities included in them.

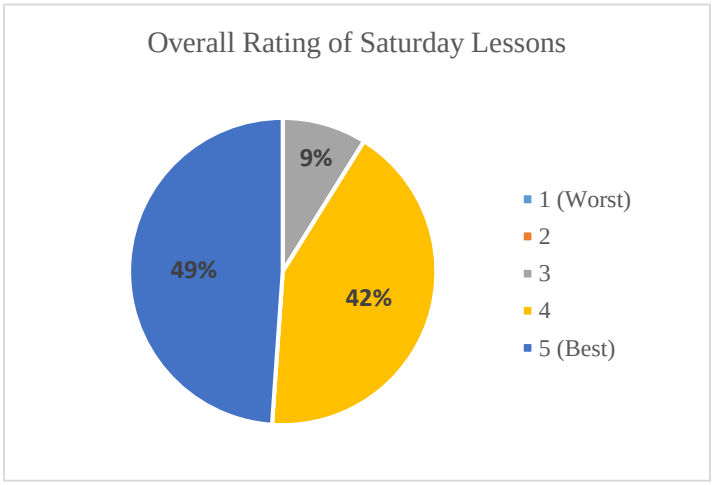
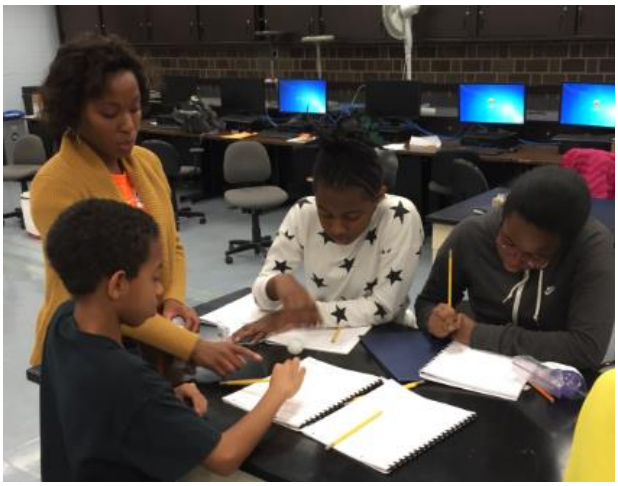


Figure 1: Overall Rating of Saturday Lessons. Students in attendance during the fourth Saturday scored the lessons as a whole; and not as individual lessons.

Mentorship & Leadership Opportunities in the Program

Prior to the start of the Saturday program, current undergraduate students in the College of Engineering, College of Education and the College of Liberal Arts & Sciences were recruited and trained as volunteers. Over 30 student volunteers were recruited, and these represented disciplines such as physics, math, elementary education, and engineering. Thirty-four percent of these student volunteers were from underrepresented minority groups.



An undergraduate student volunteer working with a group of middle school students.

A volunteer training for all 32 student volunteers was hosted by the coordinators of the program, where expectations were discussed and the curriculum was briefly studied. Attendance to the volunteer training was required for all undergraduate student volunteers. Approximately 10-12 student volunteers were present every Saturday, in which they had the opportunity to closely interact with the students. Student volunteers helped the groups of middle school students work through the problems, assisted them with experiments, and joined them for lunch. On the last Saturday of the program, when the students and their parents participated on a day-long fieldtrip to UIUC, mentors were able to meet the students' parents and interact closely with them as well. During these four Saturdays, the undergraduate student volunteers and the middle school students were able to share stories, experiences, and their passions for the STEM subjects. Not only does this interaction benefit the middle school students, but it benefits the student volunteers as well, as research has shown that

while mentees develop greater confidence and attitudes when they have a mentor, the mentors themselves receive an outlet to give back to their community, learn teaming skills, and increase their confidence[12].

We also gathered students' opinions regarding the involvement of undergraduate student mentors in the program, and an overwhelming 95% of the students said they enjoyed being able to interact with them (Figure 2).

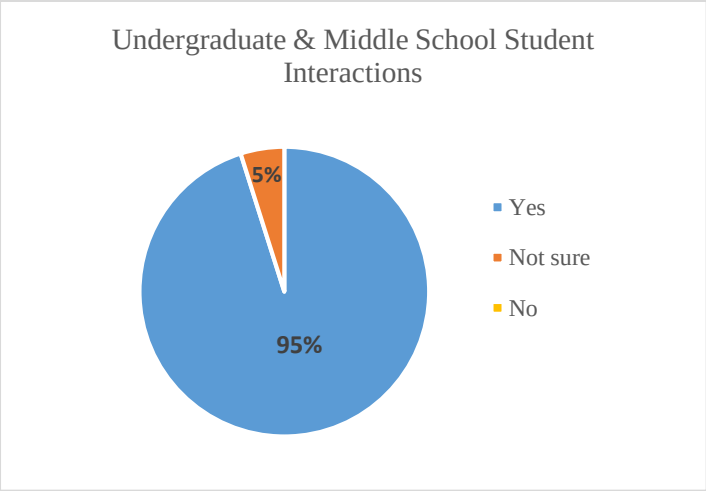


Figure 2: Undergraduate & Middle School Student Interactions. Students in attendance during the fourth Saturday were asked if they enjoyed interacting and working with the undergraduate student volunteers.

In the future, we hope to encourage more robust mentor/mentee relationships by allowing for more interactions outside of the program. These strategies could include a PenPal program, or a visit day on campus so students can see what a typical day at a university looks like for their mentors.

Future Plans

Research shows that providing long-term engagement is crucial in moving youth from simply having an interest in science to actually having the skills, knowledge, and self-efficacy to pursue careers in science[13]. Long-term engagement has also been shown to instill a sense of belonging to the program by building a collective identity, and by allowing participants to feel like they belong to the physical space they are in[14]. For these reasons and with a partnership across multiple sectors, this program seeks to sustain and build on the engagement of the participants by expanding the program to include six Saturday sessions instead of four, and by launching an additional grade every academic year (*e.g.*, grade 8 in 2016-17, grade 9 in 2017-18, etc.). The goal is to build a solid 6th – 12th STEM pipeline with a strong emphasis in mathematics that will supplement the students' existing public school education (the K-5 is already in place through ChiS&E). Starting in the summer 2016, we will also launch a four-week summer camp for 7th graders. The summer camp will be adding more grades in parallel with the program. It is important to note that the program will continue to be offered at no cost to the participants.

Student knowledge and ability will be measured before and after each academic year in order to determine what the students have learned and where we can improve the effort. This has already been done for the 7th grade fall program, and we plan to continue it in spring 2016 and subsequent semesters. We will also assess the teachers, by observing their efforts with the students and having them do self-assessments. Participating students will also be tracked throughout the program, to determine whether or not they were successfully entrenched into the STEM pipeline.

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