Evaluation of the Impact of a STEM-focused Research Program on Minority High School Students' Self-Efficacy and Interest in STEM Research and Careers

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Introduction

This paper evaluates the impact of a STEM-focused research program on the self-efficacy and interest in STEM research and careers of minority high school students (grades 9-11) in the North Carolina Mathematics and Science Education Network Pre-College Program (MSEN) at North Carolina State University (NCSU). The mission of MSEN is to prepare underserved students at the middle and high school levels for careers in STEM. The STEM research program consisted of two components: a research methods course and summer research experience that were designed to provide exposure to research methods, engineering design principles and STEM careers and professionals. Undergraduate students in the minority engineering program (MEP) at NCSU served as mentors to the MSEN students throughout the project.

It has been widely reported that there is a shortage of individuals with the technical skills required to meet current STEM workforce demands. According to an executive report issued by the President's Council of Advisors on Science and Technology (PCAST) in 2012, there is a projected need for 1 million more STEM professionals than the U.S. will produce at the current rate over the next decade [1]. More specifically, the U.S. will need to increase the number of students who receive undergraduate STEM degrees by about 34% annually over current rates to meet that need [1]. The recruitment and retention of more ethnic minorities into STEM fields is needed to assist in closing the gap between the current supply and demand for STEM professionals. Minorities have historically been underrepresented in STEM. In fact, underrepresented minorities (African American, Native American and Hispanic) earned just 18.9% of all bachelor's degrees awarded in science and engineering[2] in 2012 compared to 60% for their white counterparts [2].

A number of research studies in recent years have investigated the factors that contribute to the lack of participation and persistence of underrepresented minorities (URM) in STEM. Many of those studies [3-5] cite academic underpreparedness, financial obstacles, stereotype threat and a lack of role models as factors that have contributed to the disproportionate number of minorities in STEM. Additionally, researchers [6-8] have reported a link between self-efficacy and STEM degree attainment among URM. Self-efficacy refers to a person's belief in his or her ability to successfully perform a given task or behavior [9]. According to Bandura [10], self-efficacy determines the course of action people choose to pursue, how much effort they put forth in given endeavors and how long they will persist in the face of obstacles. Students with high self-efficacy beliefs typically persist at higher rates in STEM versus students with low self-efficacy beliefs. The aim of this study is to evaluate the impact of exposure to STEM research on underserved and unrepresented students' self-efficacy and interest in STEM research and careers.

Program Overview

A research methods course was developed for high school students (grades 9-11) in the MSEN program and was taught in three parts over the three year project period: introductory- 9th grade, intermediate-10th grade and advanced-11th grade (Fig. 1). Students entered the program as ninth graders and continued through to the junior year. The course was designed to provide exposure to research methods in STEM, engineering design principles and STEM careers and professionals. Course topics included research and career opportunities in STEM, the scientific method, engineering design process, data collection and analysis, fundamentals of Microsoft Excel and statistics. Each part of the course consisted of 10 class sessions for two hours per session as a part of the MSEN Saturday Academy. A two hour SAT/ACT preparation session was included as an ancillary component of the course. Class sessions were held in an academic building on the campus of NCSU.

Course Learning Objectives

At the conclusion of the course students should be able to:

1. Define the term research.
2. Describe examples of research being conducted in STEM fields and the potential impact of that research on society.
3. List examples of career opportunities available in various STEM fields.
4. Collect scientific data in a laboratory setting.
5. Analyze and interpret simple scientific data generated in the laboratory.
6. List and describe the steps of the scientific method.
7. List and describe the steps of the engineering design process.
8. Compare and contrast the scientific method and the engineering design process.
9. Describe the difference between quantitative and qualitative data and provide examples of situations where each is used.
10. Demonstrate knowledge of the basic functions of Excel and how it can be used in scientific data analysis.

Students participated in a 2-week long summer research experience in years 1 and 2 of the program where they worked on engineering design-focused research projects under the guidance of MSEN teachers and MEP mentors. MSEN students were required to complete the research methods course in order to participate in the summer experience. In year 3, students participated in a 1-month summer research experience where they lived on campus and worked approximately 35 hours per week for three weeks in a STEM faculty member's lab on a small research project.

Program Implementation

Selection criteria for program participation included: 3.0 GPA in 8th grade, completed Common Core Math II and achieving a 3.0 GPA in the first semester of the 9th grade year.

Initially, 43 ninth grade students were invited to join the program but only 37 agreed to participate. In year 1, the average number of participants each Saturday was 27, but ranged from 22 to 31 across the ten class sessions. In year 2, the average number of student participants each Saturday was 29, but ranged from 20 to 33 across the ten sessions. There was some attrition in

Figure 1. Pre-College STEM Research Experience Model

the first two project years. Four students left the program after year 1 for various reasons. Three new students that met the aforementioned selection criteria were added to fill those vacancies, resulting in a total of 36 participants in year 2. There were 28 student participants in year 3. Table 1 provides greater detail about student demographics during the research course and the summer experience.

Table 1. Student Demographics during the Research Course and Summer Experience

Research Course			
	Year 1	**Year 2**	**Year 3**
	n=37	n=36	n=28
Race			
African American	73%	78%	71%
Asian/Pacific Islander	3%	3%	3%
Latino	8%	6%	11%
Multiracial	-	3%	-
Native American	-	3%	3%
White	16%	8%	11%
Gender			
Male	59%	67%	68%
Female	41%	33%	32%
Summer Experience			
	Year 1	**Year 2**	**Year 3**
	n=33	n=36	n=26
Race			
African American	82%	78%	69%
Asian/Pacific Islander	3%	3%	3%
Latino	6%	6%	12%
Multiracial	-	3%	-
Native American	-	3%	4%
White	9%	8%	12%
Gender			
Male	59%	67%	69%
Female	41%	33%	31%

Year 1

The course began with a basic orientation to the program and overview of the elements of scientific research and the engineering design process. Subsequent sessions focused on exploring the science and engineering of prosthetics. Students conducted research, designed a prosthetic limb, developed a materials list and budget and created a prototype limb based on their design. Participants also conducted several smaller experiments throughout the course where they were asked to generate a hypothesis and collect and analyze data to demonstrate use of the scientific method.

Program participants spent nine full days on campus during the summer experience. Students explored transportation systems research and engaged in extended learning opportunities including campus tours, industry tours and presentations from invited guest speakers. The summer research experience focused on the Engineering Grand Challenge, Restore and Improve Urban

Infrastructure. Students learned the history of autonomous vehicles and how to program Lego® Mindstorms® NXT-G to simulate car movement through various traffic situations. They wrote a paper detailing their experience, created a PowerPoint presentation, and presented their findings to a session with parents and the wider university community.

Year 2

The first half of the intermediate research course focused on the Grand Challenges for Engineering. Students conducted hands-on research methods activities related to several of the grand challenges. The theme of the second half of the course was "Engineering Challenges in Flight and Space" with a focus on drone technology. Students conducted preliminary research on drone technology including communications, power systems, propeller/motor design and system integration. The research was presented by the students during a poster session held on the last day of the course.

Participants spent ten days on campus as a part of the summer experience in year 2. Students explored drone technology research and continued to engage in extended learning opportunities. The preliminary knowledge of drones gained in the course allowed students to delve deeper into drone technology research, including exploration of the current state of the technology, applications of the technology and the impact of drones on our society. Student teams examined the effect of component mass on the battery life of drones. Each team created a PowerPoint presentation highlighting their findings at the end of the summer experience.

Year 3

The focus of the final year of the research methods course was the preparation of students for the culminating summer research experience with a STEM faculty mentor. Course activities were designed to allow students to gain a greater understanding of and practice in: 1) formulating research questions, 2) developing experimental designs, 3) creating and testing research hypotheses and 4) data collection and analysis. Students were tasked with integrating both the scientific method and engineering design process in the modeling, design and testing of a mousetrap car. Students explored the effect of wheel size, type and number, center of gravity, mass and friction on mousetrap car performance. Participants were divided into design teams of 3-4 students. Each team designed a mousetrap car, developed a hypothesis on how the mousetrap car would perform, designed an experiment to test the hypothesis, carried out the testing and collected and analyzed the data. At the end of the project, each team created a research poster and presented to STEM faculty judges and parents during a poster session held on the last day of the course.

A number of guest speakers were invited in to discuss topics that would prepare students for the summer experience. For example, a licensed speech pathologist gave a talk on how to give an effective oral presentation. There were also presentations by STEM faculty and professionals discussing topics such as research, careers in STEM and the workplace.

Participants spent four weeks on campus as a part of the final culminating research experience in year 3. Three of the four weeks were dedicated to working 30-35 hours per week on a small research project in the lab of a STEM faculty member while the final week was designated for preparing their oral presentations. The summer research experience began with about 30 student participants. However, only 26 students were able to complete the entire four week experience. There were 13 STEM mentors representing a variety of disciplines including civil and industrial engineering, food science, veterinary medicine, agricultural and human sciences and natural resources. Each STEM mentor was assigned 1-2 students. Faculty-student assignments were based on indicated student interest. On the final day of the summer experience, students gave an oral presentation of their research to an audience consisting of project staff, parents and faculty mentors.

During the final summer experience, students lived in a residence hall on campus, ate their meals at the university dining halls and were given access to the gym facilities, all in an effort to provide them with a more comprehensive view of what college life might be like.

Evaluation

The evaluation of this project was informed by a variety of sources, including program artifacts, observations, focus groups/interviews, and surveys. Evaluations were conducted at the end of each project year. Table 2 below shows the alignment of data sources for each evaluation question.

Table 2. Evaluation Questions Aligned to Data Sources

Evaluation Questions	**Data Sources**				
	Project Documents and Artifacts	**Observations**	**Focus Groups & Interviews**	**Content Assessment**	**S-STEM Survey**
1. Did program staff create and implement a high quality, engaging research methods course and summer research experience?	X	X	X		
2. To what extent did participation in the STEM program impact students' science and mathematics competency levels?	X		X	X	
3. To what extent did participation in the STEM program impact student enthusiasm for science and mathematics?	X		X		
4. To what extent did participation in the STEM program impact students' interest in pursuing careers in research or other science-related areas?			X		X

Project Documents and Artifacts

Program documents and artifacts were used to help inform evaluation efforts and to ensure the data collection instruments developed were closely tied to the program design and goals. They were also used to assess whether it was aligned to the priorities of the funding agency.

Research Course Development and Implementation, Summer Research Experience Observations

Non-intrusive site observations occurred during the research course development process. These observations were conducted during select planning meetings. Informal visits were made during the research course and summer research experience. Detailed field notes were gathered and analyzed to provide requisite answers for the evaluation questions.

Focus Groups and Interviews

MSEN teachers, student participants, and mentors participated in either focus groups or interviews to determine the program's impact on the items outlined in the evaluation criteria. Semi-structured interview protocols were used to guide discussions with participants. Interviews and focus groups were digitally recorded and transcribed. A reflective analysis process was used to analyze and interpret interviews and focus groups.

Test of Students' Science Knowledge

A student science content knowledge assessment aligned to the instructional goals of the research course was developed and administered at the onset and conclusion of each part of the course.

S-STEM Survey

The S-STEM Student Survey measures student self-efficacy related to STEM content, interest in pursuing STEM careers, and the degree to which students implement 21st century learning skills. The survey was administered in a pre/post format at the beginning and end of each project year.

<u>Findings</u>

Results are organized by evaluation question and are discussed both in terms of project year and in aggregate.

1. Did program staff create and implement a high quality, engaging research methods course and summer research experience?

Evaluation data from the three project years show that the STEM research program was successful in creating experiences that were high quality and engaging. Through observation during the school year and summer sessions, students were found to be highly engaged with their projects and exhibited high levels of on-task behavior. Students appeared to enjoy the time they spent working on their various projects. When asked during the student focus groups, one student compared her experience in this program to programs that were attended in the past, *This is the best one that I have done, in my opinion. The most fun one ever. We're not even using the real resources they use to make a real medical prosthetic leg. We're just using foam and pipes. It's cool that everyone has the imagination and creativity to make it out of normal stuff.*

One student described the program as "*fun*"; while, another student elaborated by saying, "*It's fun because you get to have new experiences*." Similarly, when asked about how the program compares to their science classes in school, several of them expressed that many of their school courses lack a hands-on aspect. As a result, many of the students felt the manner in which the program was designed helped them understand the content better. Overall, the students rated the program content, teaching/learning techniques, and staff support very high. Students shared,

On a scale of 1-10, this is a 10. My classes are 7 or 6 ½.

We have college students who come help us, so they better understand, if we don't understand something that would help us understand in a way that older people would explain it to us. I really liked how the college students came to help us. I mean not even just with the college students. The teachers are helpful, too. Basically, everybody is there and has your back 100%.

I think I liked this better. I really liked the hands-on part. Science at school we don't do as much with researching and may not have the time to build.

Even though I have this technology class that I'm taking and we do similar projects, they don't have the college students there helping. It's nice to see their experienced opinions and be able to have their insight. They help you reach it in a good way. They won't tell what you want to know but they will give you helpful hints and personal experience to decide what they've done in the field.

There was a high level of interest in science among the students in the focus group at the beginning of the program and it continued through the final year. A student in the focus groups in year 3 expressed a desire to take more classes and another described being excited about learning research options available to them. The students shared,

I've pretty much always liked math, but I've taken more science courses I've noticed, over there this past year than I usually would have.

I necessarily know if it made me like it more, but it made me more excited about doing don't research in it and seeing what kind of possibilities are there with it. As a topic, I like it the same, but maybe more excited about it.

When interviewed, students suggested that their favorite portion of the program was the culminating research experience in the summer of 2018. It was evident how much the students gained in knowledge, maturity and confidence over the course of the program as they gave oral presentations of the research that they had conducted with their faculty mentors. The students were poised and articulate and did an excellent job presenting the research. The majority of faculty mentors commented on how well prepared the students were and how they wished they had more time to work with them. Some parents were astonished to see their sons and daughters deliver a talk on what seemed to them to be important topics that they never dreamed their child would be working on.

2. To what extent did participation in the program impact students' science and mathematics competency levels?

In year 1, there was a slight improvement in students' math and science competency levels as determined by the pre- and post-content knowledge assessment for the introductory course. The content assessment consisted of 21 multiple choice questions and four open ended questions addressing both math and science content. The mean number of correct responses on the multiple choice portion was 15.7 on the pre-test (n=29) and 16.29 on the post-test (n=28).

The open ended questions asked students to define research, name at least three of the Grand Challenges for engineering, list the different types of engineer with which students are familiar, and state current topics in STEM research. The vast majority of students were able to provide a definition of research. While many of the answers could be expanded to more fully describe research, a basic level of understanding was expressed by most of the students. The post-test results elicited many of the same definitions for research. Some of the definitions given by students included:

- Developing background information on a certain topic.
- Research is the act of accumulating information on a given subject to learn more about something to improve upon it or invent something new.
- Process of discovering or finding answers to a question
- Research is the looking up and learning about a topic you didn't know much about in the first place. You research topics before experiments.
- Using resources and information like data to find solutions to everyday problems.

Students' responses varied when asked for examples of current areas of research. Research areas mentioned by students could be broadly broken into the following areas: computer, energy, environmental, and medical. Sample responses given by students on both the pre- and post-test included:

- Cancer research
- Climate change
- Cybersecurity
- Ebola
- Food being grown faster without additives
- Fracking
- GMOs
- Medication using stem cells

Information collected from students during focus groups in year 1 revealed that several of the students felt the program enhanced their knowledge of science, but math knowledge was only enhanced for a select few students. The research methods course focused on the engineering design process and science content related specifically to the projects being completed. When specifically asked about science skills, most students provided positive answers. Student responses included, *It's better now for me*

Yes, a lot

Before this program, I was really good at science. I feel like it added more to what I really knew.

The lead teacher explained how he worked to incorporate science content into the research methods course. While students were exposed at the beginning of the prosthetic limb, greater care could be taken to integrate scientific aspects more fully along the way. He stated,

I think that on the front side of the prosthetic project, Newton's Laws were presented. We were able to cover forces and motion, force equals mass times acceleration. Some of them had not thought about how the project connected to science. They were focused on just making a device. Some of them had aha moments and started to make connections. We also looked at compression and tensile strength as well as angles in relation to remaining limb and how the prosthetic limb would fit. What angle does the foot portion need to be at and how much flexing should be possible when a person walks with the prosthetic limb? How will your product fair? What considerations did you put into making your product? I think students are absorbing information but still developing a context for how science exists outside of a traditional classroom.

As stated earlier, students found difficulty connecting to the math concepts being presented as they did not mirror content in their current high school math classes. The lead teacher discussed his attempts at integrating math and science into the research methods course to build skills and show connections,

On the math side, we had the students to pull down data, graph it and begin to recognize trends. We wanted students to be able to extrapolate what data point may come next. We had them think about how much they may need to engineer a prosthetic limb for child growth. Will it work when the child is 60 pounds and then grows to 110 pounds in high school?

Student mentors suggested that the research methods course did not specifically enhance specific science or math skills in students, but the course was more about exposure and developing their critical thinking skills. The student mentors shared,

I think it definitely helps them as far as the critical thinking that they are going to need, and they have had a lot of exposure to various topics. Whether it's circuits or they come up against a problem when they're building the prosthetic device that they are doing now. Other subjects will pop up and it's just a good learning moment for them to learn something new or they may not be exposed to in the classroom.

To me, they have an understanding to see how things work in a way, when we did those small projects like the bridge, the science factors for what is required to have a decent bridge then they can implement any ideas they may have and incorporate into their project *and create an even better one. I get the feeling that their science application has improved bit by bit.*

In retrospect, the mentors felt they could have done a better job of showing students the connections to both science and math as they worked with students in the development of their projects. They suggested that future courses be much more intentional with incorporating specific activities that build both math and science skills.

In year 2, students slightly improved their math and science competency levels between the two administrations of the Intermediate Content Knowledge Assessment. There were 20 multiple-choice questions and four open-ended questions on the assessment. The average score on the assessment was 72% on the pre-test (n=34) and 80% on the post-test (*n*=34). Similarly, there was a slight improvement in math and science competency between the pre and post Advance Content Knowledge Assessment. The average score on the pre-test (n=20) was 80% and 81% on the post-test (n=20). The open-ended questions asked students to define research, name three current topics in science, technology, engineering, or mathematics, name at least three of the Grand Challenges for engineering, and list three steps involved in the engineering design process. All students (100%) provided an acceptable definition for research on both administrations of the content assessment. During the pre-test, 65% of students were able to provide at least three current areas for research; however, on the post-test 97% of students were able to do so. In terms of the Grand Challenges of Engineering open-ended questions, students struggled. On the pre-test, 38% of students were able to provide three of the challenges as required. On the post-test, students' level of proficiency rose to 74%. The final question netted only 12% of students who could accurately provide steps in the engineering design process on the pre-test. This amount rose to 44% on the post-test.

Information collected from students during the focus group in year 2, showed that the participants were pleased with the content they learned and felt the program enhanced their knowledge of science and math. This was a rewarding finding given that most students commented in year 1 that the program did not enhance their math skills. It appeared that our efforts to more closely align math concepts with the projects and course activities were fruitful.

When specifically asked if the program helped enhance their science skills, most students felt that the course enhanced their skills but in a more applied manner.

The subject matter was good. It was good learning something new… something we had never done before made it interesting.

The class affects the technology side of my science knowledge. Instead of learning about biology, chemistry, ecosystems, or physics, straight out, you learn applications of these to problems.

Math skills were enhanced during the sessions with the Math teacher. Students expressed their gratitude for the teacher. Students were much more confident in their own math skills due to time spent studying math. The lead teacher complimented students on their growth in the area of mathematics. He shared,

> *The students are progressing with their Math skills, including ACT preparation and applied math topics linked to the hands-on projects, lasers and drones application and basic Statistics.*

One student added,

> *I have been in advanced math classes for a while so I am not taking the typical classes for a 10th or 11th grader. The review and tips that Ms. XX gives us for the ACT and SAT is important because it has been awhile for me. It really is a refresher. It will help be prepared when I take those tests. It is really helping me with those skills.*

Another student shared,

> *I am more of a science person. Math is not my thing. When we took the practice ACT last year, I did the worst in math. We have been able to go through all of the material and that really helped me. I feel much more confident going into my junior year.*

3. To what extent did participation in the Broadening STEM Participation program impact student enthusiasm for science and mathematics?

The program had a positive impact on student enthusiasm for science and to a lesser degree mathematics according to students, the lead teacher, and mentors. By virtue of the students tapped for the program, most had high levels of enthusiasm before the onset of the program. When asked about student enthusiasm, the lead teacher measured the degree to which students were enthused by their level of engagement in the course he oversaw. He offered,

> *I've seen a great deal of increased enthusiasm. Not to be negative, but the greatest step function is looking at apathy. You have to consider that we are asking students to come in on a Saturday morning. You're dragging in, but within 15 minutes of being engaged, then all of a sudden you're happy, bubbly. You're conversing with your team; you're collaborating on things that work and things that didn't work. I have seen this grow more and more as the semester has progressed. I am seeing students who are quiet and reserved come out of their shell.*

One student felt the class exposed that she liked a particular aspect of STEM. She explained,

> *I realized that I really, really liked the science more than building things...instead of the actual hands on part.*

While a minor discovery, this has potentially helped her and other students narrow down what they are excited about and want to explore more.

When interviewed, students shared they truly enjoyed the science/engineering content presented to them and the manner in which they could interact with the information through guided study. Three different students stated, *This program is different from my science classes at school. The teacher knows all the answers and here I get to explore and get to decide what I want to know the answers to. It is much more exciting to me.*

To piggyback on what [Student X] said, I do not think the rigor is more than my school but I like how independent this program is. At my school, there is a lot of teacher help that leads you to where you need to go. This program lets you explore and decide where you want to go. It has been good to learn how to research on my own and not have to depend solely on the teacher. I want to be able to explore on my own more.

It does not compare to as much to my math and science classes but it compares to my technology and engineering class that I took last year. It is similar in that you start with a problem and design an experiment to test out a theory you might have about solving it. It takes the concepts from math and science but applies them to technology.

The lead teacher discussed the growth mindset he witnessed in students from year 1 to 2 of the project. Students were motivated to do a good job on their projects and often used breaks to continue their work and have discussions with other students, student mentors, and himself.

An example is comparing the students final research project presentations last year (9th grade) compared to this year (10th grade) is night and day. Even leading up to the projects did not require as much motivation; some, but not as much. In short, I believe the fear of presenting was less. The students are beginning to talk more about college readiness and preparedness plans with me and the MEP Students. The same is for the type of work they want to do. Some quieter students are beginning to bring their lunch back to the classroom and talk about life challenges in school and career exploration. While other students have started coming back to work on their projects during lunch. This is a beautiful scene to watch...students enjoying their passion! Once the students are fully awake, they are engaged and working towards the lesson plan objectives. All projects were completed on time this semester.

4. To what extent did participation in the Broadening STEM Participation program impact student interest in pursuing careers in research or other science-related areas?

The program piqued most students' interest in potential careers in a STEM-related field. When asked what fields they might want to pursue, several mentioned various forms of engineering and medicine or medical research. When asked if the class influenced their interest in a STEM career, some students said it remained the same as a they already had a strong interest, a smaller amount said it increased, and one student of the ten students interview said that interest decreased. Different students said,

I feel like it strengthened whether or not I want to be an engineer.

I never really thought about engineering, to be honest. It was never something that I really thought about in depth but find it interesting now.

The S-STEM provided information about how interested students were in a predetermined set of STEM areas. The survey results show that there was some fluctuation in responses across some of the areas from pre- to post-test administrations (Table 3).

Table 3. STEM Career Interest Proportion of Agree/Strongly Agree

Career	Proportion “Interested/Very Interested”			
	Fall 2015	Summer 2016	Summer 2017	Summer 2018
n	31	32	32	24
Physics	58%	50%	34%	52%
Environmental Work	42%	44%	41%	57%
Biology & Zoology	52%	47%	56%	52%
Veterinary Work	29%	22%	22%	35%
Mathematics	45%	34%	44%	35%
Medicine	71%	66%	56%	52%
Earth science	35%	47%	44%	48%
Computer Science	65%	63%	59%	53%
Medical Science	68%	59%	47%	48%
Chemistry	61%	50%	56%	39%
Energy	45%	22%	50%	39 %
Engineering	77%	72%	91%	78%

When comparing STEM preferences between gender on the post-test in year 1, girls expressed greater interest in medicine (91%) and medical research (82%) than boys (52% and 48%, respectively). On the other hand, boys showed greater interest than girls in engineering (85% vs. 45%), physics (67% vs. 18%), and computer science (71% vs. 45%). Because the differences were great, program staff made an effort to incorporate many different STEM areas into the projects and course activities in year 2 in order to appeal to the interests of both genders. Table 4 details the level of interest during the pre- and post-test administrations disaggregated by gender for year 1.

Table 4. STEM Career Interest Proportion of Agree/Strongly Agree by Gender

Career	**Proportion "Interested/Very Interested"**					
	Total		**Male**		**Female**	
	pre	post	pre	post	pre	post
N	31	32	14	21	17	11
Physics	58%	50%	79%	67%	50%	18%
Environmental Work	42%	44%	43%	52%	50%	27%
Biology & Zoology	52%	47%	50%	48%	64%	45%
Veterinary Work	29%	22%	21%	5%	43%	55%
Mathematics	45%	34%	64%	48%	36%	9%
Medicine	71%	66%	71%	52%	86%	91%
Earth science	35%	47%	36%	57%	43%	27%
Computer Science	65%	63%	86%	71%	57%	45%
Medical Science	68%	59%	59%	48%	79%	82%
Chemistry	61%	50%	65%	57%	57%	36%
Energy	45%	22%	64%	33%	36%	0%
Engineering	77%	72%	88%	86%	64%	45%

Students had the opportunity to meet STEM professionals in many different disciplines over the course of the program. Guest speakers offered unique insight about academic requirements, job tasks, work-life balance, and compensation. One student was particularly influenced by a guest speaker from Met Life. The presentation was rich with information and allowed the student to narrow down his field of interest. The student shared,

> *I'm thinking about more about computer engineering and I think this program has helped me understand what it is about. I looked into the program. I'm going to complete an application for an internship there.*

Students also had the opportunity to learn about the majors and student work experiences (interns/co-ops) of the MEP mentors. This exposure impacted student views of what careers may be available and interesting to them, as well. One mentor shared that a student had an interest in biomedical engineering. The mentor, a biomedical engineering major, was able to have conversations with the student about what her studies are like and classes that they could take to become better prepared to take on such a major. She stated,

> *I had one student in particular, talking about biomedical engineering. I started asking him what is it that you like about it, and I started introducing him to biological engineering, since he was more interested in the cells and the bio side. It's also important for these students to understand more real life applications to some of the things they are doing and also to just start having conversations outside their projects and what sort of careers they may be interested in and why.*

Other mentors welcomed students to discuss their career interests with them if they desired. The relatable nature of the mentors allowed students to speak freely. In the end, these informal conversations may influence or open up new doors to areas previously unknown to the students sparking further career exploration.

A few students remain unsure about their career interest; however, the research methods course proved to still register impact. The course affected one of the students in a profound way in terms of him beginning to see that he has the aptitude to be STEM professional even if he opts not to. He said,

> *I am not sure that I want to be an engineer, but I know that if I wanted to and put my mind to it I could. The ones I have met are regular people.*

Although, the student may not pursue STEM, more specifically engineering, the course was successful in building student confidence and providing information about the possibilities of what can be. Career paths are not limited.

One student expressed that she is still undecided about her major. She initially entered the program with a strong interest in medicine, but the exposure to engineering has her thinking about exploring engineering options. She stated,

> *Even if I choose to go back to my first love of medicine, I see the benefit in learning the engineering concepts. I see how the engineering process can be used in every aspect of life.*

Lesson Learned & Future Plans

There were a number of key takeaways that were not necessarily reflected in the formal evaluation of the program but can be viewed more as anecdotal evidence based on day-to-day observations of project staff over the course of the program. We include these below for those that may have an interest in replicating this program or similar types of programs in the future.

- **Incorporate a variety of STEM areas into the projects and course activities**. Although the heavy focus on engineering in year 1 caused a surge in interest in engineering fields among males, it may have alienated the female students who expressed greater interest in the medical sciences. In year 2, we offered a session focused on the engineering grand challenge, Advance Health Informatics that was well received by female students.

- **Offer multiple projects of varying lengths**. Interest levels varied from student to student and from year to year. Therefore, it is suggested that multiple projects be offered to accommodate more of those interests and to allow students to have greater agency in what they choose to study during the course of the program.
- **Discuss failure**. Many of the students expressed frustration during course projects and the summer research experiences because their experiments did not go exactly as planned. As a result, mentors and teachers made an effort to drive home the point that many scientific discoveries and/or innovations have come from failed attempts. Once students began to grasp this concept, they were better able to handle when things went wrong because they understood that it was a normal part of the scientific process.
- **Provide opportunities for reflection**. Students should be given opportunities to think reflectively about their research projects. This could be done through the use of weekly journals, for example.
- **Utilize peer mentors**. We cannot overstate the value of the MEP mentors. The students consistently commented from year to year about how much they appreciated and valued the presence of the undergraduate students. The impact of seeing someone that looked like them be successful in engineering was tremendous.
- **Expose students to research best practices.** We did not require students to keep research notebooks in year 1 of the project. In an effort to make the research experience as authentic as possible, we implemented the notebooks in years 2 and 3. It was our hope that this would help to build the students' STEM identities in addition to making it easier for them to keep track of their research.

Due to the overwhelmingly positive response received from student participants, parents, STEM faculty mentors, student mentors and others, our next step is to seek additional funding to scale up the program and investigate the broader impact of STEM research experiences on underrepresented students' persistence in STEM fields. Additionally, we aim to explore the longitudinal impact of the program on students' decisions to pursue STEM studies.

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