Ms. Hines and the Sick 5th Graders -– Making hands-on outreach and learning about the Environment engaging through the use of Case Stories!

Mrs. Janie Gina Locklear, NC A&T

I am a Senior Civil Engineering major with 5 years experience teaching elementary science. I returned to school to obtain a second degree in engineering after learning that I have a stronger passion for design and problem solving. As a teacher, I emphasized to my students daily the importance of science and engineering and promoted love and passion for the related work by using hands-on experience with EVERY lesson taught. My philosophy was and always will be learning occurs best through experience!

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Abstract

Inclusion of minority and low income students in STEM (Science, Technology, Engineering, & Math) early in their educational careers is vital to help guide them on the track for higher education. Both peer and societal pressures that tell girls they should shy away from STEM are especially prevalent in the middle school grades for female students. Therefore, before peer pressure and popular culture lures them away from self-efficacy in math and science, outreach to females outside of the traditional classroom is crucial. For this research project, thirteen middle school students were invited to attend a summer camp hosted in the environmental engineering laboratory at North Carolina Agricultural & Technical State University. Three environmental and public health "cases" or stories were developed to increase the student interest in science and environmental engineering. The girls were grouped into teams and each group was assigned one of the three cases in which a community member or pet became sick due to an unknown microbial hazard in water. They were asked to become scientists to solve the cases. The hands on experience included collecting environmental water samples from a local park and teaching the girls how to use environmental equipment to test for bacteria levels in the water to learn about a real-world environmental problem – water quality and water impairment. The use of the "case" to teach environmental and public health showed increases in the student's interests in the sciences and engineering. The participants were given short pre- and post-surveys to assess the experience by collecting qualitative and quantitative data. This paper will discuss the cases used for the camp using the "cases in the sciences" method used during the camp and the impact hands-on experiences had on increasing student interest.

Introduction

A need for an increase of minority women in the STEM (Science, Technology, Engineering, & Math) professionals is prevalent. This paper shares with the reader how mere efforts of using fictitious cases based on possible real world scenarios can help increase the interest of female students. In particular, this method can be used to recruit, retain, and guide young minority girls into STEM inquisition, higher order thinking, and hands-on problem solving that can possibly one day lead to increased numbers of minority women in STEM professions. Literature suggests that the lack of women scientists as heroines, role models, and mentors adds to smaller numbers of women STEM professionals, hence, resulting in lower numbers of females in the science and math areas. [4] With the goal of increasing the visibility of

women in STEM and featuring STEM women as role models in the case studies and the camp, our hypothesis is the use of the cases coupled with hands-on STEM activities will increase the female participants' self-efficacy hence making STEM careers more tangible for minority girls, especially the field of environmental engineering.

A one week camp was funded by the Boroughs Welcome Fund at North Carolina A&T State University during the week of June 10 – 14 to minority rising 7th and 8th graders at Guilford County middle schools that are labeled as Title I schools . Title I schools are funded with federal money to improve the achievement of low-income students. This group is targeted because low socioeconomic status girls are less likely to pursue careers in science and math related fields.[1] The camp was led by two STEM female faculty and an undergraduate female engineering student.

Figure 1: Participants of Girls in Science Lab learning to using pipettes.

After months of strategy and curriculum planning for the camp, applications to the camp were made available to students currently in the 6th and 7th grade; these applications included a student essay, parent essay, and a teacher recommendation. Using a rubric, the students that would benefit most from the camp were invited to attend. These targeted students showed an obvious interest in the science, math and engineering fields and exhibited past performance indicative of success in the areas. Once students were accepted, the invitations to be on campus before 8 a.m. on the first day of the camp were sent out. Parents were requested to verify that their child would be attending the camp and to complete necessary forms for precautions and permission.

The overall purpose of the camp was to develop and instill deeper interest in the sciences and engineering to young, underprivileged minority women. As girls grow older, it is common for misconceptions of professionals in STEM occupations to deter their further intrigue and interests in career related fields. Thoughts of scientists, engineers, and related 'nerds' for that matter, paint stereotypical pictures of old men wearing glasses, with fair skin, white hair, and a

long white lab coat. To test this concept, the girls participated in a Draw-A-Scientist Activity. After discussing their ideas about what a "traditional" scientist looked like, they talked to the camp leaders about women in STEM. The girls were then asked to work in groups to draw photos of a scientist. Figures 2 are photos of their drawings where the girls have now drawn female scientists with biology and environmental related cartoons.

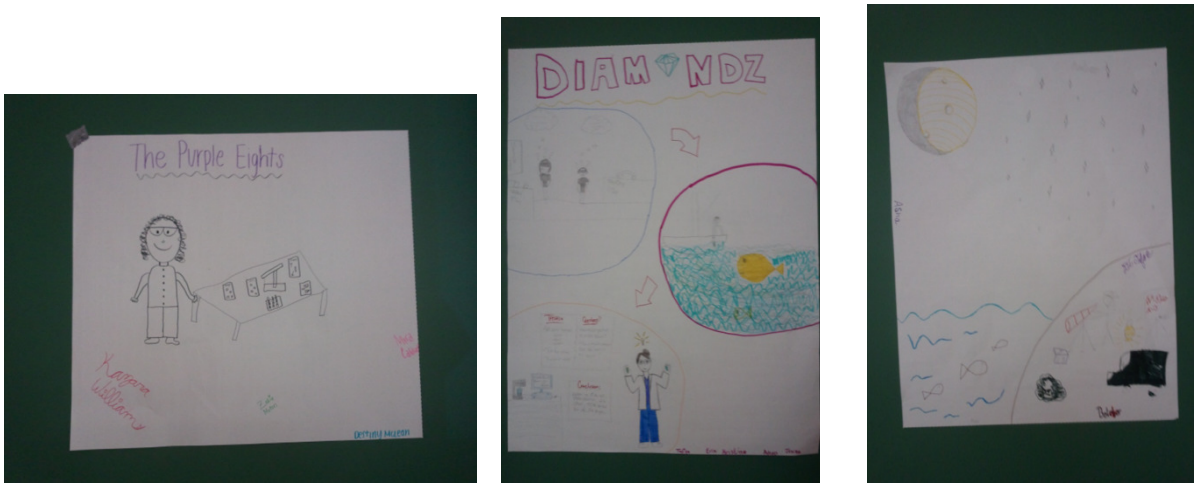

Figure 2. The drawings from the Draw a Scientist Activity

Outreach Program Implementation and Use of Environmental Case Studies

A thesis by Brenda Gustafson (1985), a candidate for a Master's Degree in Education, reveals in research that using case studies with sixth grade girls brought out several themes in responses from the girls. The themes included that hands-on activities allowed the girls to feel more personably involved with learning, to be more autonomous, and to experience school in a way that connected them to their everyday life.[3] As in the case with this study, our idea was to allow the girls to experience science and engineering in a way that they can see the relevance of the work to their live and use the hands-on activities to peak their interests in the STEM fields as a possible career choice.

The camp met for 9 hours each day and a detailed schedule of events was followed in order to keep the young girls busy working as scientists in a lab solving a simulated real world issue that provided hands on experience related to an environmental engineering problem. During the camp, the girls were randomly assigned to one of three groups and designated a case study to solve by the end of the week. The following illustrates each of the three case studies that were assigned during the week of the camp:

Case 1

A teacher calls in sick to her principal the day after she and her 5th graders took a field trip to a local park. The principal is notified that 17 of the students' parents have also called in sick. The teacher, Ms. Hines, goes to her doctor and reveals the activities of the prior day's field trip and is told that it may be an E. Coli bacteria infection. In the story, the teacher and the students visited a playground area at the park and fed the ducks and geese near the lake.

Case 2

A dog owner, Anthony, notices that his dog Jake is lethargic after a day playing a game of fetch at the local park. The dog was playing fetch near the bank of the park lake. They did not see a sign warning in the area where they played warning park visitors not to play in the water. Anthony takes his dog to the vet and describes Jake's symptoms and previous activities. The veterinarian notifies Anthony that Jake may be suffering from an E. Coli bacteria infection.

Case 3

In case 3, a mom is cleaning her home and realizes an extra turtle is in her children's terrarium. Her kids tell her that they found the turtle at the lake in the local park. The mom is concerned that the boys may get sick from their new turtle because it came from the lake at the park they were playing at the day before. Like the other cases, the mom visits the doctor with her sons and the turtle may have transferred E. Coli bacteria from the lake to the terrarium.

Figure 3: Participants learn to properly pipette contaminated water into microtubes to be tested for E Coli.

Day 1 of the camp (Monday) began with instruction on how to safely use a science lab tools including the importance of wearing goggles, gloves, and lab coats. Students were allowed to tie-dye their lab coats to keep them from sticking with their idea that scientists where "boring" white lab coats. Students were introduced to lab equipment and learned how to use tools that would be used daily in the lab to analyze water samples. They learned about the scientific method in analyses, the importance of accuracy and precision, and data collection in a lab notebook. The girls were also taught how to use PowerPoint to make presentations so that at the end of the week, they could present their work to parents and other guests. Each group of girls was assigned one of the cases to investigate. The case studies were written in a play format where the students could act out the events from their cases. By doing this, the groups played the "role" of the scientists and were given time to plan how and where they wanted to collect their water samples during the field trip on day 2. As the groups developed their sampling plans, the camp leaders helped them with the process of developing their plans and discussed

how bacteria in water can cause illness. The girls learned that as the “doctor” or “scientist” they needed to prove their characters from the stories were exposed to water or locations that were positive E. Coli.

The second day of camp began with a discussion of their cases and the tests needed to determine whether or not E. Coli bacteria is the culprit of each case. The students, along with the help of the camp administrators who are an immunologist and environmental engineer, learned how to perform an Enzyme Linked Immunosorbent Assays test (ELISA test) can be used to determine a positive E. Coli infection in the victims. For the educational outreach, the girls were provided prefabricated samples from the “victims” in each case. The young scientists determined that the patients in the scenarios were each infected with the E. Coli bacteria so their next step was to determined that the source of contamination. A discussion was led between the three groups and it was determined that during the trip to the local park where they could collect water samples from the case story areas. The playground area and location where the characters fed the ducks was collected for Case 1, various areas in and around a large lake where the dog played was collected for Case 2, and water samples from the dock where the children found the turtle was collected for Case 3.

Figure 4. Girls collecting water samples based on their Case scenarios

Day 3 (Wednesday) activities including using petri dishes with agar to incubate and grow bacteria from the water samples collected and air samples around the environmental engineering lab that the camp was using. This particular activity was used to help show students the importance of having professionals in the STEM fields in our everyday life. What if there was no one to test for contaminates in our drinking water and the air we breathe? What if there was no one to clean out the contamination of our water before we drank it? These were just questions posed in our young students minds as they placed their dishes inside the incubator. Afterwards, the students continued with a case related experiment to complete a positive/negative prescence assay for E coli using EDVOTEK Assay kit #951 and quantifying the E. Coli levels using the IDEXX assay.

Day 4 began with likely the most favorite part of the camp because the students could see if their water tested positive for E coli and they could quantify the bacteria levels. Using UV black light, the student samples would glow in the dark if they were positive. Students learned that their samples were positive for the E. Coli bacteria using the positive/negative and learned how to measure the Most Probable Number (MPN) of bacteria in the water samples using IDEXX. From the previous days in the camp, the girls learned that the EPA standard for recreational water use should be less than 200 MPN E coli/100 ml of water. The girls learned how to count the wells on their IDEXX trays and use the IDEXX chart to calculate the MPN E coli per 100 mL in their samples. The students assigned Case 1 determined their water samples collected in the duck and geese feeding area exceeded EPA standards and E coli swabs from the playground area were not high enough to cause illness. The students assigned Case 2 determined that the dog was exposed to unsafe levels of E coli in the water area near the paddle boat area where the dog played fetch. Case 3 measured only 8 MPN E coli/100 ml in their water samples collected from the dock area and concluded that the turtle did not contaminate the terrarium.

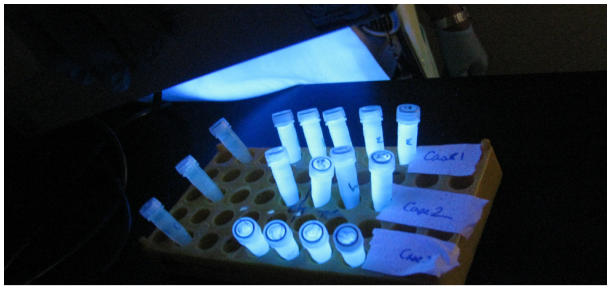

Figure 5: UV black light is used to determine if the contaminated water is positive for E. Coli. A glow indicates the presence of the disease.

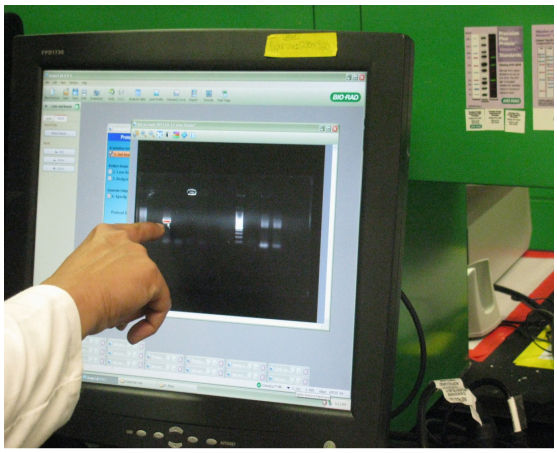

Figure 6: Students learn about the strands of DNA extracted from their sample of contaminated water.

Directly after MPNs were calculated, Polymerase Chain Reaction (PCR) testing was done by the students using their water samples to isolate the E-Coli DNA and allowed the students to get a visual on what DNA strands look like once spread out. In real life, this testing would be done to hopefully match a source of the E. Coli's DNA to the victim's E. Coli DNA. The students at this point realized accurate and precise one must be to get results; only one student was successful at performing and getting results from the PCR testing.

On the final day of the camp (Friday), students began to organize their work on posters and on presentations for the closing ceremony. Students showcased their week long study after a brief role play of the case for their parents. The students revealed the results of their cases and whether or not the local lake was the source of contamination for their victims. After presentations, a small rewarding ceremony took place to present each student with their cleaned

lab coats that had been decorated with a completion patch of the camp logo and a certificate of achievement. Each young girl was presented as "Future Doctor" with their last name announced.

Results

Assessment

Pre and post-surveys were administered to the students to determine learning gains, increased self-efficacy, increased interest in science, and their interest in pursuing science careers. These surveys combined provide a comparison of prior knowledge and interests to post knowledge and interests (Table 1). The data collected favors the importance of providing real-life case studies for students to work hands-on in life-like situations that use science to save money, prevent sickness, and even death.

Table 1: Career choices of pre/post surveys.

What job area are you most interested in?	
	% Difference pre vs post GSL Camp
Agriculture	15.38
Arts/Entertainment	-23.08
Business	-7.69
Education/Teaching	-15.38
Health Care/Medicine	15.38
Law	-15.38
Science	15.38
Sports	0
Technology/Computers	-7.69
Other	15.38

Results of these surveys showed that there was a 15% increase in the interests of science and Health Care/Medicine and a 23% decrease in the Arts/Entertainment Industry. The study showed that there was an increase in the knowledge of physical and biological factors that help predict the safety and potability of water. The knowledge of Polymerase Chain Reaction (PCR), a way to separate DNA and RNA and multiply it for testing, increased by 31% along with 100% knowing, by the end of camp, what a pipette is and its use. Best of all, the girls' recognition of female engineers and scientists increased with an understanding that scientists can be anyone and look 'normal' in distinction to what society teaches.

An enrichment survey was also given to the girls at the end of camp that requested feedback on their feelings, perception, and attitude toward science (Tables 2 - 7). All students agreed or strongly agreed that they have a better understanding about what scientists do. These same students feel better about being able to learn science after attending the camp. Numerically, 92% are more excited about science and are more aware of the importance of science in everyday living and stated they were more interested in learning science. More than 77% are encouraged to take more science in the future while 85% are more encouraged to get a science related job or career when they grow up. After the program, 92.3% indicated they were interested in continuing in science.

Table 2. Survey questions about science related fields in which students answered "Agreed" or "Strongly Agreed."

	A.	S.A.	% A. and S.A.
This program helped me understand science better.	7	6	100
I feel better about being able to learn science.	10	3	100
I learned some things I can use in science class at school.	4	7	84.6
I think I am more aware of the importance of science in everyday living.	9	3	92.3
I tell my family and friends about the things we do in this program.	5	6	84.6
I am more excited about science.	8	3	84.6
I think I have a better understanding what scientists do.	7	6	100

Table 3. Responses for science competency

Question: How would you describe yourself as a science student?				
	Frequency	Percent	Valid Percent	Cumulative Percent
Okay	2	15.4	15.4	15.4
Good	5	38.5	38.5	53.8
Very good	6	46.2	46.2	100
Total	13	100	100	

Table 4. Responses for participant's interest in participating in a similar camp or recommending it to friends

	No	Uncertain	Yes	No answer
Would you like to participate in another program like this one?	1	1	11	0
Would you recommend this program to a friend?	1	2	10	0

Table 5. Responses for participants' interest in science

How would you describe your interest in science before this program?			
	Frequency	Percent	Cumulative Percent
A little interested	3	23.1	23.1
Sort of interested	2	15.4	38.5
Interested	3	23.1	61.5
Very interested	5	38.5	100
Total	13	100	

Table 6. Responses for participant's change in feelings about science

Has this program changed your feelings about learning science?			
	Frequency	Percent	Valid Percent
Yes, I am more interested in learning science.	12	92.3	92.3
Yes, I am less interested in learning science.	1	7.7	7.7
Total	13	100	100

Table 7. Responses to participants' thoughts about science classes in the future

Has this program encouraged you to think about taking more science classes in the future?		
	Frequency	Percent
Yes, I am thinking about taking more science classes in the future.	10	76.9
My thoughts about taking science classes in the future have not changed.	3	23.1
Total	13	100

Parental Response

The parents were also given a post survey to get an idea of their viewpoint from the child's learning. One parent reported that on the first day, the child showed the camp notebook, which contained all vocabulary and experiments for the week, explaining that she had learned a

lot already, leaving the parent very impressed. Another was ecstatic for the opportunity to participate while others thanked for enhancing their daughter's love for science. An overall reaction was that the children wished for more time, even suggesting that for the next Girls in Science Lab camp, the girls be allowed to stay on campus overnight.

However, the most rewarding feedback came through parental emails days after the camp was over. Several parents sent an email just to re-thank the camp leaders for what their daughter had learned and for encouraging them to want to further learn science and one day exploring a career in the field. One parents email was so rewarding, it has to be mentioned in it it's almost entirety:

> *"I wanted to take time out to thank you again for accepting Jesika into the Girls in Science program. This camp helped to keep the chemistry flames burning within Jesika. She is still talking about the camp with excitement. Last week when we left the camp she went to Charlotte for the weekend to spend time with family that flew in from all over the country. She sat the entire family down and presented her PowerPoint presentation from the camp. She shared detail-by-detail of her exciting camp experiences. She has attended numerous camps over the years, but the Girls in Science camp has made the most tremendous impact on her. Thank you so much!"*

> *"I truly hope that this camp continues because of it's positive reinforcement for girls that express an interest in the sciences. It's also gives them an opportunity to explore other sciences while understanding that their career choice can be exciting while making a life changing impact on the world."*

Conclusion

The feedback received from the program is reassuring to the notion that continuing the camp will help increase the number of minority women in the science, technology, engineering, and mathematics fields. Both the student and parent responses indicated in the various forms of feedback signify that case studies that allow young girls to do hands on experiments to solve real life problems will actually increase the awareness of the importance in STEM fields and that anyone who develops an interests can become scientists beyond the stereotype. With the Girls in Science Lab (GiSL) Program, we also hope to get similar track results to a longitudinal case study. Several studies such as the one by Fadigan and Hammrich (2004) track the performance of student participants post program. In the Fadigan and Hammrick (2004) study, 152 minority women who participated in a Women in Natural Sciences program during high school were surveyed to see how the program effected their career choices. These women came from urban, low-income, single-parent families. The surveys revealed that 109 of the women enrolled in college with a majority of the women in STEM related careers.[2] Since the primary goal of the GiSL is to increase minority girl's interests in STEM, we hope that future results of possible

surveys will reveal that our program played a role in the career choice of the young ladies who are involved.

Figure 8. Girls in their personal tie-dyed Lab Coats

Overall, we feel the camp provided an excellent method to extend outreach for girls in STEM. We made the most progress in the development of the environmental engineering based cases that were appropriate for the middle school grade level and incorporating the laboratory activities such that the girls could interpret the results for their final group presentation. The next phase of the program is to offer the academic year program. We anticipate being able to apply for more external funding from alternate private sources who have expressed an interest in the program. The goal will be to offer the program at minimum cost to participants. We will also have the opportunity to offer the program through our NCAT Summer Outreach Office as part of their summer camp series.

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