An Effective Student Implemented STEM Outreach Program for Title 1 Schools

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Abstract

Science, Technology, Engineering, and Math (STEM) are well documented areas for improved instruction at all levels. Despite the increased emphasis and additional resources, some students are missing the STEM revolution. The U.S. does not sufficiently tap the talents of the nation's students as evidenced by the underrepresentation of women, racial-ethnic minority, and low-income students. Complex barriers decrease the potential students' ability to achieve formal STEM education. Students may not have access to information about college options, while others question their aptitude within the STEM profession. A lack of academic preparation may derail their pursuit of STEM fields. Fortunately, several outreach, mentoring and recruitment activities can diminish barriers and increase retention. The Citadel is working to build a STEM Outreach program with the local public schools and implemented by the students at The Citadel. This paper will provide an overview of a new proposed STEM outreach program that was initiated last year with a local Title 1 school and is currently being refined. This initiative innovates and advances the STEM skills the students need to ensure their success in a technologically advancing world. It is important to note that this particular program is designed within the framework of 3rd – 5th grade secondary science education. With limited scope, the program and activities were designed to inform and generate interest. One goal is to expose young students to the world of engineering to prepare and encourage them to study STEM fields. Response to these programs has been very positive. The quantitative results, which include pre and post outreach assessments, support the effectiveness of the STEM program.

Keywords

K-12 Outreach, STEM, Program Evaluation, Title I Schools

Introduction

On a national level, the demand for engineers is growing as many employers discover that job applicants lack mathematics, computer, and problem-solving skills necessary for the workplace. One of the national K-12 STEM goals is to increase scientific literacy among the general public[1]. Charleston, South Carolina is becoming a regional technical location with many businesses, manufacturers, and educational institutions seeking long term success through human capital[2]. On a local level, bringing the STEM initiative to Title 1 schools is a goal specific in the tri-county area. The goal is to increase the amount of technical students/workers in the local area, according to Dr. Conway Saylor of The Citadel. The Citadel's STEM Outreach Program, developed in the summer of 2014, is an ongoing initiative with the following specific goals:

1. Familiarization with STEM, introducing students to STEM
2. Recognizing STEM in daily life (the importance of learning STEM)

3. Building confidence in approaching STEM in future classrooms
4. Improve problem solving skills of students

The Citadel initiated a STEM Outreach Program with two local Title 1 schools in the summer of 2014. Pre and post surveys assessed student interest in STEM and their future goals for STEM education and/or employment.

Demographic

Tourists flock to Charleston, South Carolina every year for its sandy beaches, historic downtown, and variety of shopping. Give a closer look and one will see that Charleston is marked by poverty. According to the United States Census, “there are between 58,884 and 68,890 people in Charleston living below the poverty line. This means that more than 20 percent of the population is considered poor”[3]. With a significant portion of the population living in impoverished conditions, the students from these areas do not have access to the same resources that would encourage not only STEM education but post-secondary education.

In the Charleston County School district 55% of the student population is made up of minorities[4]. This means that The Citadel STEM initiative is not only reaching high risk students that live in low income households and encouraging them to consider college, but also helping to increase the amount of minority students that take interest in STEM fields. Often times, students are not exposed to topics in STEM fields because the teachers in primary education schools lack the funding to bring STEM activities to the classroom[5].

As part of the Elementary and Secondary Education Act of 1965, Title I provides government aid to low income school districts. The original purpose of Title I was to serve remedial education programs; currently, Title I serves to help all disadvantaged children meet the state’s academic standards[6]. Due to low funding, Title I schools do not have the resources to provide STEM curriculum, nor is it a top priority when the students are coming from a lower income background. Title I schools receive extra grants and funding for the high percentage population of children from low income families. The extra funding helps ensure the students meet the rigorous academic standards that all schools in the state uphold. However, when the student’s homes do not reinforce what happens in school, how much would be retained if a STEM program was initiated?

Design of the Program

The demand for STEM careers is expected to increase, at a rate of approximately three times faster than other careers; however, the number of students to meet this demand is not increasing at the same rate[3]. With very little increase in adequately prepared students, there is a problem generating interest in STEM in the K-12. Students are not always exposed to topics in STEM fields because it is not uncommon for teachers to lack training for activities that will capture the attention of the students[5]. In order to generate interest, one of the main goals of this program was to show the students how STEM was part of their daily life. The instructors / facilitators showed them that not only do they see STEM every day, but they are a part of it. STEM is an integral part of our daily lives, and they are part of the process of using, understanding, and innovating with math and science to improve the world around them - and those improvements start with them.

Addressing the Program Goals

To develop comfort with problem solving and STEM topics, the students were introduced to the topics slowly, while drawing connections relevant to the student's daily lives. For example, one of the topics was understanding pH and the difference between acids and bases. With this, instructors were able to connect bullying, an all too familiar issue, to acids, bases, and indicator solutions through the use of a story. By explaining how a weak acid mixed with a strong base was similar to a student on a playground having an altercation with a larger bully. Instructors know the strong base overpowered the weaker acid; however, students observed the whole thing and were able to tell that the pH had changed overall – because the "tattle-tale" (indicator solution) revealed the true pH of the new solution - the acid had weakened the base. This went on with multiple examples of how weak bases and strong acids: would the strong acid over power the base? And so on. For the instructors, the story might seem a little unrelated; however to the children, who could relate to the story of the large bully and the smaller student on the playground, their work indicated that they had an understanding. In using small anecdotes and real world connections, the students were able to develop comfort with the elevated vocabulary.

Although there was never a concept inventory, observations and collected work indicate that the children were learning when connections were made to their everyday lives. When designing activities, it was important to never allow one correct answer or winner. Failure was encouraged because the program was designed, in part, to teach them that the best things come from failure (this is part of the student's growing more comfortable when confronted with STEM questions). This allowed them to take away the stress, and work together in groups without fear of judgment or being wrong. Because there was never a black and white answer, it allowed everyone to be successful in one way or another.

Instructors doubled as mentors. One of the greatest lessons taught was about the design process: identify the problem, know the constraints, plan and brainstorm, model it, and make it better. Every activity in the classroom involved the design process. The design process was stressed to them as the foundation for problem solving - for any problem, sports, family, school, and self-growth. Using the design process is how they were taught - each lesson opened up with identifying a problem relevant to today's society: electricity, conserving clean drinking water, layout of a city and food desserts. As a class, they would come up with constraints. For example, with clean drinking water, the activity was to design water filters. After informing the children of the global scale of the issue and how living on the coast in the United States is not something they had really ever seen, the students came up with the constraints of cost efficiency, available resources (they couldn't use more rocks and cotton than they had available, etc.), size (the water filter had to fit in the pre-approved form), portability, and the type of water in the filter. Students raised concern over filtering out leaves versus filtering out germs. After that each student drew out their own filter, and after their design was approved for testing, the participants made their filters and they were tested for the constraints they developed. Each student had to evaluate the effectiveness of their filter and every student had to come up with one thing, at least, to improve his/her design.

At the beginning of the program, each student was given a lab book. It was explained that scientists have their own work, and do not "cross-contaminate" with other students. For each activity, the students used another page in their lab books. Their lab books were nothing more than white computer paper stapled together; however, sometimes it's those little things that make the difference with children. Having a page for each activity made it possible to build upon activities and make each activity reinforce concepts from an earlier day. At the end of every other lesson, a trivia game was played to constantly reinforce the terms, concepts and activities. This pushed the students to work in groups, and collaborate as teams. Team collaboration was stressed as an important part of working in a STEM career because diverse groups increase creativity and innovation in the workplace.

See Table 1 (below) for a complete outline of the program.

Approximate Cost

This program was designed with the tri-county school system in mind; however, any school would benefit from a cost efficient program. For an eight week initiative, the budget was $300.00. This indicates that on a national level, there is potentially little excuse not to be able to bring STEM to K-12 environments. Each activity was linked to each other in terms of supplies, and this was explained to the students as recycling, which allowed for another door to open in terms of real-world issues and classroom discussion. The following (Table 1) shows a rough outline of the 8-week program with what the activity was, what was covered, and the most basic supplies, most of which can be found at your local dollar store.

Table 1: Activities and *Basic* Supplies

Week	Title	Topic/Outline	Key Vocabulary	Supplies Needed
1	STEM	Define STEM, lab safety, Elephant tooth-paste demonstration, "slime"	Science, Technology, Engineering, Mathematics, Experiment	Borax, Water, Food Coloring, Popsicle Sticks, Small Cups, Ziploc Bags
2	Gasses	Imploding Can, Fire Extinguisher, Coke & Mentos	Implosion, Explosion, Carbon Dioxide, Density	Empty Soda Cans, Hot Plate, Small Candle, Empty 2L Bottle, Baking Soda, Vinegar, Mentos, Coke
3	pH	pH testing	Acid, Base, Reaction, Indicator Solution	Acids and Bases, Indicator Solution, Egg in Vinegar, Droppers/Trays
4	Water Properties	Chromatography Butterflies, Density Boats	Chromatography, Density, Design, Absorption	Coffee Filters, Markers, Pipe Cleaners, Aluminum Foil, Marbles

5	Clean Water	Water Filters	Sustainability, Activated Carbon, Ecosystem, Design Process	Empty Water Bottles, Coffee Filters, Gravel, Sand, Cotton, Activated Carbon
6	Cities & Shapes	Designing a City	Civil Engineer, Transportation Engineer, Architect, Resources	Paper, Scissors, Tape, Markers
7	Circuits	Tilt Lanterns	Electron, Electricity, Circuit, Energy	Light Bulb, Small Battery, Tilt Switch, Tape, Small Jar
8	College Day	Review Game, Pin the diploma on the graduate	College, Career, Scholarship, Education	STEM questions, pin the diploma on the graduate game (homemade)

Program Effectiveness

The following (Table 2) shows the question scale used on the survey administered to the two Title 1 schools. Unlike the traditional Likert scale, this scale was used as an attempt to provide choices, but not too many choices, to the young student population.

Table 2: Question Scales

Questions 1-7			
0	1	2	3
Not at all true of me!	Maybe a little true of me.	I think this is true of me.	This is very much true of me!
Question 8			
1	2 3 4 5 6 7 8 9		10
Terrible			Great

The following table (Table 3) shows the pre and post survey results from the two Title 1 schools that participated in the STEM Outreach program. Overall results show that the outcomes were generally good given the scale (0-3) and had a mostly positive trend by the end of the program.

Table 3: Survey Questions and Results

	SITE 1				SITE 2			
QUESTION	PRE	POST	CHANGE	% DIF	PRE	POST	CHANGE	% DIF
1. I am excited about engineering	2.5	3	0.5	20	1.4	1.8	0.4	28.6
2. I am excited about science	3	3	0	0	2.4	2.2	-0.2	-8.3
3. I might want to go to college one day	2	2.5	0.5	25	3	2.8	-0.2	-6.7
4. I might want to study science in college one day	3	2.5	-0.5	-16.7	2	2	0	0
5. I might want to study engineering in college one day	2	2.5	0.5	25	1.2	1.4	0.2	16.7
6. I might want to be a scientist one day	3	3	0	0	0.4	1	0.6	150.0
7. I might want to be an engineer one day	2.5	2.5	0	0	1	1.4	0.4	40.0
8. Rate overall experience	10	10	0	0	8.2	8.8	0.6	7.3

The program was implemented in two local schools: at site one, participants came as they were available and did not attend every session; however many students came to the final day where a great topic of discussion was college. This is mirrored by a 25% increase in the desire to attend college one day. At site two, the same group of students came to every week's session, and did not include the final activity for college.

For site one, students had to pay to attend the summer program offered by the school. With the demographics of the area, some students could not attend on a regular basis, due to financial reasons. At site two, the students were part of a year round development program, with no cost to participants because it targeted the demographic. This allowed regular attendance, and, arguably, more of a drive to participate. In light of the two scenarios, the data was limited. Not only was the data limited, but the instrument to gather the data, the survey packet, was not appropriate.

The survey was designed before the program, by an outside source; therefore, the goals measured by the survey packet did not align directly with the programs goals or the activities. Upon arrival, and after interacting with the students, it became clear that the literacy level was below what was expected. This was later tested and confirmed; the average literacy level of the students was below the grade level. Since the instrument was designed before having met the children, the vernacular was too advanced, so the survey often times had to be read aloud to the students and the vocabulary had to be defined. For future programs, one of the key improvements that needs to be made is to redesign the survey for the appropriate audience and the specific goals to be measured: e.g. design the program, and then the survey.

The activities planned will often have to be tailored for the group. Despite all planning efforts, once the children get involved, they will run with what interests them. Every volunteer had to be prepared with basic, fundamental knowledge in order allow the children's natural curiosity to flow and for them to develop their problem solving skills. However, the instructors still needed to be able to guide students to the correct answers without telling them verbatim. One of the key things practiced was not to make STEM all science or all engineering. It is important to show the connections between science, technology, engineering, and mathematics. Through these connections, the students were able to find things that excited them. Everyone was able to work on the same activity; however, each group focused on a different aspect of the exercise. This created a dynamic learning community.

Figure 1: Participant A

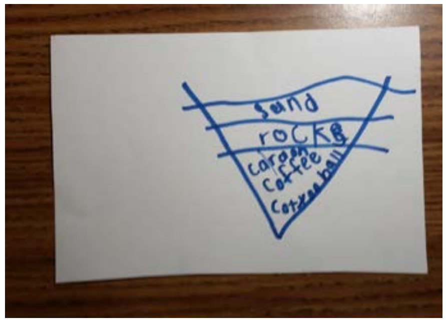

Figure 2: Participant B

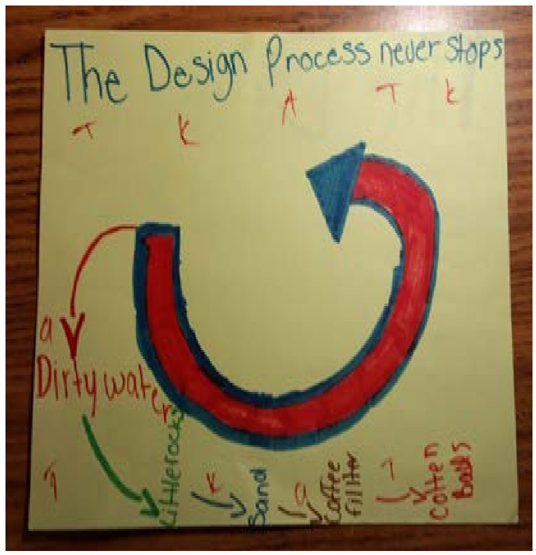

Figure 3: Participant C

Figures 1, 2, and 3 are all examples of participants' work from the same class. As one can see, three different participants did the exact same activity in his/her own way. This activity during week five was making a recycled water filter system. The students learned about the issues surrounding clean drinking water and designed their own filters. The direction given was to draw a preliminary design for the water filter; after the design was approved by an instructor, the students received their materials to construct their first model.

One of the main goals of this program, aside from developing student's problem solving ability was to build confidence with approaching STEM in the future. The most important observations gained from the program were qualitative. Monitoring the student's interactions, work, and questions, instructors were able to measure how well the students were grasping the concepts. Though this may not be directly measurable, they hold an immense value to helping these young people in the future.

One of the greatest observations was the way the students grew to appreciate all STEM fields by the time the summer had ended. In the beginning, students talked about maybe going to college, or how they wanted to go to cosmetology school. One student was noted for wanting to work in the fast food industry. However, by the end of the program, the same students were trying to create experiments on their own - altering the activities to be more innovative. This program had given students the opportunity to quench their natural curiosity, to become more engaged, and to show a greater interest in attending college.

Conclusions

Although this program is in its first year and there is much to improve, there were some successes and lessons learned. First, to develop comfort with problem solving and STEM topics, the students were introduced to the topics, and connections were made to illustrate relevancy to the student's daily lives. In using small anecdotes and real world connections, the students were able to develop comfort with the elevated vocabulary. Secondly, the activities were designed to allow endless correct answers or open solutions. Failure was encouraged with a goal to teach them that the best products / solutions come from failure. This allowed them to take away the stress, and work together in groups without fear of judgment or being wrong.

Future work for this particular STEM Outreach program for Title 1 schools will include a revised survey. The survey must be appropriate to measure the goals of the program, so close coordination is required of program goals, ways and means to measure, and activities. Additionally, the survey must be literacy level appropriate so students can answer on their own, without any external influence. This can also measure any increase in STEM vocabulary.

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