Planning, Implementation, and Impact of K-12 Outreach Program Project ENspire

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Abstract

In this paper, girls' views of engineering before and after completing hands-on engineering activities through Project ENspire are evaluated. Project ENspire was held at Mississippi State University (MSU) in 2016 and 2017. Participants were placed into small groups and given three engineering-related activities to complete with mentorship. To encourage the participants to explore new activities on their own, the event activities were designed using common items. Additionally, each participant was given a Book of ENspiration, detailing the activities' goals, materials, and engineering topics/disciplines. Project ENspire is structured around upper-elementary girls, when many girls begin losing interest in STEM subjects. The goal of Project ENspire is to inspire girls in this sensitive age group to create, design, and explore. Surveys administered show that the event had a positive impact on the participants' opinions of engineering and their ability to be successful in the field. Future plans include expanding the event to other cities and improving the pre- and post-surveys. Overall, this program has been successful in exposing young women from diverse backgrounds to engineering topics and design practices and is working to inspire STEM interest in participants.

Keywords

K-12 engineering outreach, STEM education, hands-on activities

Introduction

For the past two years (2016 and 2017), Project ENspire has been held at Mississippi State University (MSU). Girls from the greater Starkville, Mississippi area in the 4th and 5th grades were invited to come and were led through hands-on engineering activities. The event was free to all participants. Each year included three activities that covered various engineering topics and/or disciplines.

Many school curriculums are missing thorough exposure to STEM topics. One way universities combat this shortcoming is by hosting outreach events for K-12 students. The Citadel held a STEM outreach program for 3rd-5th grade students aimed to encourage participants to pursue a career in the STEM field[1]. The program lasted for eight weeks, and each week covered a different STEM topic and had an activity to reinforce the topic covered. When planning outreach programs for K-12 students, it is important to understand effective ways to hold such a program[2]. Hands-on

activities are encouraged as well as giving participants a real-world application. Outreach programs should support a child's natural curiosity to explore their world.

One critical demographic focus for engineering outreach programs is females. According to 2013 data, women comprise 29% of science and engineering fields[3], but the percentage of women in engineering is only 14.9%. Research shows that girls as young as elementary aged are exposed to the stereotypes that boys are better at math and science than girls[4]. This stereotype perpetuates the negative attitude towards engineering that many females hold. A group at the Center for Pre-College Programs at the New Jersey Institute of Technology held three engineering outreach events. Two were single-gender (one male and one female), and the third was mixed gender[5]. Surveys administered showed that the single-gender female event had a more positive effect on the girls and their opinions of engineers. Therefore it is seen that engineering outreach programs aimed specifically at females have a better potential to counteract any previously held stereotypes about women in engineering. Students at the Citadel held an outreach program called Introduce a Girl to Engineering Day, and statistical analysis showed that after the outreach event, the participants showed a positive attitude towards engineering, creativity, and innovation[6].

Activities

Goals

The main goal for all of the activities was to inspire the participants to continue engineering investigation, whether this was by going home to recreate and expand on the activity or by being sparked to investigate a similar idea. The first step in accomplishing this task was using common household materials. The materials used in both years can be found at a common supercenter or craft store, and most can be found for a reasonable price. A list of the materials offered in 2017 is shown in Table 1. After the initial Project ENspire in 2016, the supplies list was refined to remove less-used materials and add ones that would provide a better use.

Table 1. Materials Offered at Project ENspire 2017

Material	
Aluminum Foil	Metal Fasteners
Binder Clips	Paper Clips
Cardboard	Pipe Cleaners
Duct Tape	Plastic Spoons
Electrical Tape	Popsicle Sticks
Floral Wire	Straws
Foam Blocks	Styrofoam Cups
Hot Glue	Velcro Stickers
Index Cards	Yarn
Masking Tape	

The activities themselves were designed with the participants in mind. They were structured and described to be miniature versions of actual engineering projects. For instance, the Popsicle Stick Tower activity was used to cover civil engineering and Newton's second law. Participants were

challenged to build a structure that could hold a large number of people. The Golf Ball Zipline activity, a crowd favorite, challenged the participants to build a miniature zipline for a plastic golf ball. Overall, the activities were designed to follow the catch-phrase of Project ENspire: create, design, and explore.

Design/preparation

Each activity was designed to be completed by a group of four or five participants in the time frame of 45-60 minutes. They all were given "real-world applications." In the first year, each group was given a set amount of materials for each activity. An improvement from the first to second year was implementing a materials store. In the second year, the participants were given a budget and "ENspire dollars." They shopped for materials for each activity and were free to choose from a variety of options. The activities from each year along with the topics they covered are:

Year One (2016):

1. Popsicle Stick Tower – the challenge was to build a tower out of popsicle sticks that could support glass pebbles meant to represent people. Newton's second law and civil engineering were discussed.
2. Plastic Golf Ball Zipline – participants built a zipline for a plastic golf ball. Height and length requirements were given. Potential and kinetic energy were discussed.
3. Coke Bottle Taxi – each group had to design a taxi using a Coke bottle as the body. The car was powered by a balloon. The taxi had to include arms that could pick up two passengers. Newton's third law and mechanical engineering were discussed.

Year Two (2017):

1. Fan Blades – each group was given a plastic container with a small motor installed. The groups had to design and build fan blades to attach to their containers. The goal was to design fan blades that created the largest wind current. The groups were given a small bolometer to measure the air flow rate. Aerodynamics and aerospace engineering were discussed.
2. Extendable Arm – the participants were instructed to build an extendable arm that could reach and grab a small cardboard box at least two feet away. Newton's third law and biomedical engineering were discussed.
3. Ping Pong Ball Track – the challenge was to build a track for a ping pong ball that started at least one foot in the air. The relationship between distance, rate, and time was discussed, and participants used the equation relating the three to determine how fast their balls were moving.

Before the event, each activity was tested by a group of college students. The students were given the same materials and instructions as the participants. This test run allowed any problems with the activity to be resolved before the event. Volunteers also had the opportunity to become familiar with the activities before they had to help a group during the event. Testing the activities has proved to be beneficial both years that Project ENspire has been held.

In addition, a Book of ENspiration was created. This book explained every activity and the engineering topics that it covers and also included a list of the materials available during the day.

The purpose of the book is to allow the participants to review what they learned throughout the day and complete the activities at home. A link to each Book of ENspiration is found below in Figure 1.

Book of ENspiration, 2016

https://tinyurl.com/ybr7bkoj

Book of ENspiration, 2017

https://tinyurl.com/yczgeypy

Figure 1. Links to Each Book of ENspiration

Implementation

Upon arrival, the participants were placed in arbitrary groups of three (four where numbers created the need). Each year, before the teams were allowed to begin the activities, a MSU engineering student would introduce the topics covered in the activity using the Book of ENspiration as a guideline. In 2016, the participants were from the Starkville area and attended the local public and private schools. In 2017, advertising was expanded to a neighboring town approximately thirty minutes away, and many participants were from this area. There were thirteen participants in 2016 and ten in 2017. The participants arrived on Saturday morning and stayed until the afternoon. Both years averaged ten volunteers. A volunteer was assigned to each group. Two more explained the activities, and the remaining volunteers ran the supplies store or floated around the groups.

Surveys

In the first year, only a post-survey was administered. In the second year, pre- and post-surveys were administered. A question asked in 2016 was, “what is one thing you learned today?” Responses to this question are given below (in the same format as the participants wrote them).

- Ingeniring is fun
- Building is hard and fun
- Newton’s Laws
- Force equals mass times acceleration

The second year had both a pre- and post-survey. Seven questions were asked on both surveys, and the results were analyzed to see any change in participant response. Ten participants filled out the pre-survey, and five participants filled out the post-survey. The response options were disagree,

maybe, and agree. The survey questions used in Watson, M., et all[6] were used to design the questions for both surveys. The questions asked are shown in Table 2.

Table 2. Survey Questions Asked at Project ENspire 2017

Question	*Statement*
Q1	I like to design and build things with my hands
Q2	I am interested in how new technologies are created
Q3	Math and science are useful to help the world
Q4	I am able to use my creativity to solve problems
Q5	I believe I am capable of designing new things
Q6	I believe I can be a successful engineer
Q7	I can name at least two kinds of engineers

To quantify the results, values of 1-3 were assigned to the responses with 1 being assigned to disagree and 3 being assigned to agree. The average responses for each question are shown below in Figure 2.

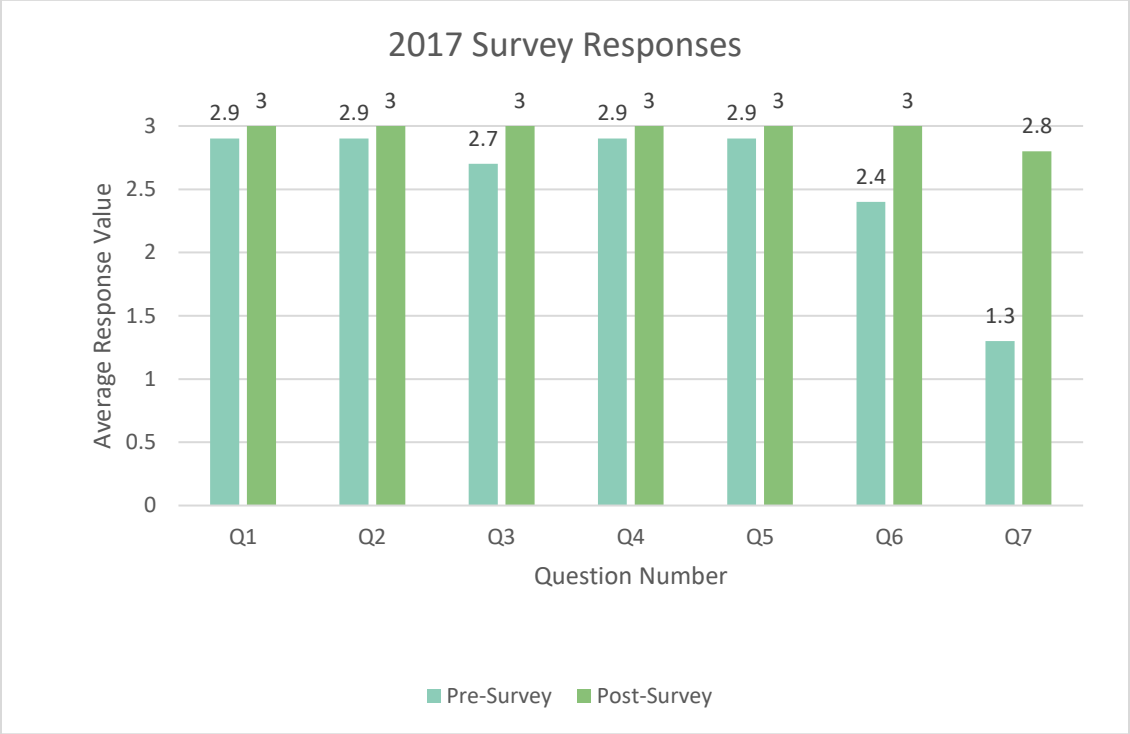

Figure 2. Responses for the 2017 surveys

The responses shown in Figure 2 show an improvement in the participants' opinions about engineering from the beginning to end of the event. The results from the last two questions show that the main purpose of Project ENspire was achieved. The goal was to expose the participants to engineering and show them that they could be engineers as well. After the event, the average response was that the participants could be successful engineers, and most of them could name at

least one type of engineering. While the sample size is still small at this time, preliminary results strongly suggest that Project ENspire has succeeded in getting young girls more familiar with and excited about engineering.

Conclusion and Future Plans

This paper describes the implementation and immediate results of an engineering outreach program for 4th and 5th grade girls called Project ENspire over a two year period. Hands-on activities were designed for groups of participants to complete. In both years, all groups were able to successfully complete the activities, and survey responses show that the program had a positive effect on the participants' opinions of engineering and their ability to be successful in the field.

The third year of Project ENspire includes hosting multiple weekends of the event in various locations across the state of Mississippi. Each weekend will be a stand-alone event and allow more young girls to be exposed to engineering. After advertising thirty minutes away from Mississippi State University proved to be successful in 2017, it was hypothesized that areas in the state not in a university city would be interested in such an outreach event and profit from it.

The third year will include research into effective advertising and how to increase numbers in the Mississippi State University area. Comparing the number and variety of participants for the two 2018 locations will provide data for how to prepare for the next year.

The pre- and post-surveys will be evaluated and changed to improve the data gathered from them. Plans include finding a consistent and accurate way to measure each participant's interest in STEM topics before and after the event. The surveys will also be improved to gauge how much of the discussed topics the participants retained.

References

1 Holt, H., Mills, A., Rabb, R., and Dimitra, M., (2015). An Effective Student Implemented STEM Outreach Program for Title 1 Schools, 2015 ASEE Southeast Section Conference, Gainesville, FL.

2 Jeffers, A., Safferman, A., and Safferman, S., (2004). Understanding K-12 Engineering Outreach Programs, Journal of Professional Issues in Engineering Education and Practice.

3 National Science Board Science & Engineering Indicators 2016, "Women in the S&E Workforce," 2016. [Online]. Available: https://www.nsf.gov/statistics/2016/nsb20161/#/report/chapter-3/women-and-minorities-in-the-s-e-workforce. [Accessed November 2017]

4 Hill, C., Corbett, C., and St. Rose, A., 2010. Why So Few: Women in Science, Technology, Engineering, and Mathematics. American Association of University Women, Washington, DC, USA.

5 Hirsch, L., Berliner-Heyman, S., Cano, R., and Cusack, J., (2017). The Effectiveness of Single-Gender Engineering Enrichment Programs: A Follow-up Study, 2017 ASEE Zone II Conference, San Juan, Puerto Rico.

6 Watson, M., Russo, L., and Michalaka, D., (2017). Introduce a Girl to Engineering Day: Assessment of Impact and Future Directions, 2017 ASEE Zone II Conference, San Juan, Puerto Rico.

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