

Introduce a Girl to Engineering Day: Assessment of Impact and Future Directions

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Abstract

Each year, the Citadel student chapter of the Society of Women Engineers (SWE), the Lowcountry Branch of SWE, and the Girl Scouts of Eastern South Carolina coordinate to plan and facilitate “Introduce a Girl to Engineering Day,” a three-hour outreach event designed to excite middle-school-aged females about engineering. A survey, adapted from the Middle and High School STEM-Student Survey developed by the Friday Institute for Educational Innovation, was administered before and after the Spring 2016 outreach event. Participants were asked to indicate their level of agreement with nine statements related to their interest in and motivation to pursue an engineering degree. Statistical analyses indicated that engagement in the event led to positive changes in participants’ engineering attitudes, perhaps most notably their belief that they could “be successful in a career in engineering.”

Keywords

K12 Outreach, STEM Attitudes, Assessment

Introduction

Each year, the Citadel student chapter of the Society of Women Engineers (SWE), the Lowcountry Branch of SWE, and the Girl Scouts of Eastern South Carolina coordinate to plan “Introduce a Girl to Engineering Day,” a three-hour outreach event designed to excite middle-school-aged females about engineering. Upon arriving, the participants are split into groups of six, with each group being led by at least one college student and one professional mentor. In groups, the participants worked with their mentors on four engineering challenges.

1. Spaghetti Tower: Participants created a tower that could support a marshmallow using only designated materials. Brainstorming, teamwork, and creativity were emphasized.
2. Polymer Bouncy Balls: Participants worked to create colorful bouncy balls, while learning about basic chemistry principles. The roles of chemical engineers were emphasized.
3. BristleBots: Participants were guided in building a robot bug. Students learned about electrical engineering, mechanical engineering, and environmental sustainability.
4. Snap Circuits: Participants constructed a snap circuit that included one accessory and a switch. This activity allowed participants to learn the basics of circuitry.

The goal of this project was to assess the effectiveness of the 2016 “Introduce a Girl to Engineering Day” outreach event. The following research questions were addressed: (1) What are the engineering attitudes of middle-school aged participants before attending an outreach event, and (2) How do the STEM attitudes of a group of middle-school aged girl scouts change after participation in a STEM outreach event?

Study Methods

Survey Development

Pre- and post-surveys were administered at the outreach event to quantify changes in students' engineering attitudes. The survey was adapted from the Student Attitudes Toward STEM (S-STEM) Survey developed for middle and high school students by the Friday Institute for Educational Innovation¹. For this study, items related to Engineering and Technology Confidence and Efficacy were included on the pre- and post-surveys. Students responded to nine statements with either *strongly agree*, *agree*, *neutral*, *disagree*, or *strongly disagree*.

Survey Administration

Pre- and post-surveys were administered to participants at the beginning and end of the outreach event, respectively. At the event, participants were identified by their table (1-20) and chair (1-6) number. Participants were allotted at least 15 minutes to complete each survey. Overall, 125 middle-school aged students participated in the event. Surveys were considered complete if the engineering attitudes items were completed on both the pre- and post-surveys ($n = 99$).

Statistical Analyses

The nine S-STEM items related to engineering attitudes were binned to facilitate statistical analyses. Responses of *strongly agree* or *agree* were given a score of 3 and assigned the title *agree*. Responses of *neutral* were given a score of 2. Responses of *strongly disagree* or *disagree* were given a score of 1 and assigned the title *disagree*.

The non-parametric Sign Test was used to detect differences between pre- and post-survey responses. The Sign Test is used to determine if there is a median difference between matched pairs. The null hypothesis that the median of paired differences was equal to zero (which would indicate no change from pre- to post-survey) was rejected for p -values of less than 0.05. Exact significances are reported for positive and negative differences of up to 25; otherwise, asymptotic significances are reported².

For each item, the number of participants demonstrating positive, negative, or no change between surveys were reported. For the Sign Test, only positive or negative changes between responses were used, while ties were omitted. When a significant median difference was detected, sign counts were used to interpret whether the difference represented a positive or negative effect. The number of ties is important because it captures whether students were not impacted because they arrived with high confidence/efficacy or whether they arrived with low confidence/efficacy and were not impacted².

Results

Confidence in Ability to “Build and Fix Things”

When asked to reflect on the statement “I am good at building and fixing things,” the outreach event led to an improved confidence for 34 participants, a decrease in confidence for 11 participants, and no change in confidence for 54 participants. Overall, for those impacted

participants who provided different pre- versus post-responses, the median of differences was positive ($Mdn = +1$) and statistically significant ($p = 0.001$).

Of the 54 participants who indicated no change in their response to the statement “I am good at building and fixing things,” 33 agreed, 12 were neutral, and 9 disagreed with the statement both before and after the outreach event. Thus, 61.1% of the unimpacted participants were already confident in their abilities to “build and fix things” before attending the event. However, 38.9% of the unimpacted participants could have been impacted by the outreach event, but were not.

Desire to “Imagine Creating New Products”

When asked to reflect on the statement “I like to imagine creating new products,” the outreach event led to an increase in interest for 12 participants, a decrease in interest for 2 participants, and no change in interest for 85 participants. Overall, for those impacted participants who provided different pre- versus post-responses, the median of differences was positive ($Mdn = +1$) and statistically significant ($p = 0.013$).

Of the 85 participants who indicated no change in their response to the statement “I like to imagine creating new products,” 75 agreed, 8 were neutral, and 2 disagreed both before and after the outreach event. Thus, 88.2% of the unimpacted participants were already interested in “imagin[ing] creating new products” before attending the event. Only 11.8% of the unimpacted participants could have been impacted by the outreach event, but were not.

Interest in “What Makes Machines Work”

When asked to reflect on the statement “I am interested in what makes machines work,” the outreach event led to an increase in interest for 20 participants, a decrease in interest for 7 participants, and no change in interest for 72 participants. Overall for those impacted participants who provided different pre- versus post-responses, the median of differences was positive ($Mdn = 1$) and statistically significant ($p = 0.021$).

Of the 72 participants who indicated no change in their response to the statement “I am interested in what makes machines work,” 57 agreed, 9 were neutral, and 6 disagreed with the statement both before and after the outreach event. Thus, 79.2% of the unimpacted participants were already interested in “what makes machines work” before attending the event. However, 20.8% of the unimpacted participants could have been impacted by the outreach event, but were not.

Confidence to “Be Successful in a Career in Engineering”

When asked to reflect on the statement “I believe I can be successful in a career in engineering,” the outreach event led to an increase in confidence for 21 participants, a decrease in confidence for 8 participants, and no change in confidence for 70 participants. Overall, for those impacted participants who provided different pre- versus post-responses, the median of differences was positive ($Mdn = +1.0$) and statistically significant ($p = 0.026$).

Of the 70 participants who indicated no change in their response to the statement “I believe I can be successful in a career in engineering,” 54 agreed, 13 were neutral, and 3 disagreed with the statement both before and after the outreach event. Thus, 77.1% of the unimpacted participants

were already confident in their ability to “be successful in a career in engineering” before attending the event. However, 22.9% of the unimpacted participants could have been impacted by the outreach event, but were not.

Belief that Engineering “Improve[s] Things that People Use Every Day”

When asked to reflect on the statement that “If I learn engineering, then I can improve things that people use every day,” the outreach event led to an increase in agreement for 17 participants, a decrease in agreement for 6 participants, and no change in agreement for 76 participants. Overall, for those impacted participants who provided different pre- versus post-responses, the median of differences was positive ($Mdn = +1$) and statistically significant ($p = 0.035$).

Of the 76 participants who indicated no change in agreement to the statement “If I learn engineering, then I can improve things that people use every day,” 70 agreed, 5 were neutral, and 1 disagreed with the statement both before and after the outreach event. Thus, 92.1% of the unimpacted participants already agreed that engineering “improve[s] things that people use every day” before attending the event. Only 7.9% of the unimpacted participants could have been impacted by the outreach event, but were not.

Discussion

Many Participants Held Positive STEM Attitudes Before Attending Outreach Event

According to pre-surveys, many participants held positive STEM attitudes, even before attending the event. Nearly 80% of participants agreed with the statements: (1) “Knowing how to use math and science together will allow me to invent useful things,” and (2) “If I learn engineering, then I can improve things that people use every day.” Prior work has supported that the ability to help others is one aspect of engineering that promotes attrition of females³.

Interestingly, nearly 80% of participants were “curious about how electronics work” before the event. Given that the field of electrical engineering often attracts fewer females than other disciplines (only 13.2% of electrical engineering degrees conferred in 2015 were to females⁴), it was surprising that the participants were so interested in electronics. Indeed, the outreach event allowed participants to experiment with basic principles of electronics (i.e., Bristlebot).

Participants clearly indicated that they would like to pursue a creative profession. Over 75% of participants agreed with the statements: (1) “I like to imagine creating new projects,” and (2) “I would like to use creativity and innovation in my future work.” Engineering is a profession that encourages creativity, and previous works have shown that this is appealing to females⁵.

Impacts of Outreach Event on STEM Attitudes were Positive

Several aspects of participants’ STEM attitudes were positively impacted by the outreach event. Many participants cited a higher confidence in their abilities to “build and fix things” and greater interest in “what makes machines work.” Given that confidence to “build and fix” was lowest among participants before the event (only 42.4% agreed that they were confident), it is promising that a short outreach event was about able to improve confidence. Prior research has shown that males, more often than females, are attracted to engineering because of the opportunity to build,

Table 3. Comparing STEM attitudes of participants before and after outreach event.

<i>Survey Prompt: Please mark your answers below to describe how you feel about each statement</i>	Pre-Test				Post-Test				Sign Test			
	Med	Disagree (%)	Neutral (%)	Agree (%)	Med	Disagree (%)	Neutral (%)	Agree (%)	Neg (No.)	Pos (No.)	Tie (No.)	<i>p</i>
I like to imagine creating new products.	3	7.1	16.2	76.8	3	3.0	11.1	85.9	2	12	85	0.013*
If I learn engineering, then I can improve things that people use every day.	3	3.0	20.2	76.8	3	3.0	9.1	87.9	6	17	76	0.035*
I am good at building and fixing things.	2	21.2	36.4	42.4	3	11.1	25.3	63.6	11	34	54	0.001*** ^{a,b}
I am interested in what makes machines work.	3	16.2	19.2	64.6	3	8.1	17.2	74.7	7	20	72	0.021* ^{a,c}
Designing products or structures will be important for my future work.	3	15.2	19.2	65.7	3	9.1	21.2	69.7	11	21	67	0.122 ^{a,d}
I am curious about how electronics work.	3	8.1	14.1	77.8	3	8.1	13.1	78.8	10	12	77	0.832
I would like to use creativity and innovation in my future work.	3	11.1	13.1	75.8	3	4.0	14.1	81.8	12	18	69	0.361 ^{a,d}
Knowing how to use math and science together will allow me to invent useful things.	3	3.0	17.2	79.8	3	3	9.1	87.9	7	15	77	0.134
I believe I can be successful in a career in engineering.	3	9.1	29.3	61.6	3	4.0	22.2	73.7	8	21	70	0.026* ^{a,d}

^aGreater than 25 positive and negative differences resulted in use of a sign test with continuity correction. Asymptotic significances are displayed.

^bZ = -3.280; ^cZ = -2.309; ^dZ for non-significant differences are not reported.

fix, or solve⁶. Although not initially confident, female participants became more confident in their abilities to build and fix after being allowed to exercise these skills.

Initially indicating relatively low interest, participants were also significantly more interested in learning “what makes machines work” after the event. Within mechanical engineering, which is perhaps the discipline most concerned with “what makes machines work,” female enrollment is typically low. In fact, only 13.2% of mechanical engineering degrees conferred in 2015 were to females⁴. Promisingly, exposing participants to mechanical engineering principles using a fun, tangible project (i.e., the BristleBot) had positive impacts on interest in the discipline.

Although interest in “imagining creating new products” was initially high (76.8% agreed that they were interested), interest was further heightened after engaging in the event (85.9% agreed that they were interested). Throughout the event, participants were challenged to exercise their creativity as they made products such as polymer bouncy balls and BristleBots. Given female interest in creative professions, allowing participants to creatively engage in the engineering design process may serve to attract them to the engineering profession⁵.

Perhaps most promisingly, there was a significant increase in the number of participants who agreed with the statement: “I believe I can be successful in a career in engineering.” While the participants were several years away from choosing a profession, this result supports that even short outreach events can positively impact females’ confidence to pursue an engineering degree.

Clear Potential for More Impactful Outreach Events

Despite the impacts on participants’ STEM attitudes, there is potential for future improvements. While students’ interest in and confidence in several aspects of engineering were positively impacted, students agreed less with statements that referred to engineering-related actions. For instance, while there was an increase in the number of participants who agreed with the statement that “I believe I can be successful in a career in engineering,” there was no such increase in the number of participants who agreed with the statement that “Designing products or structures will be important for my future work.” In essence, despite their confidence to become engineers, they did not yet see themselves as future engineers. Consequently, other positive engineering encounters may be needed to encourage participants to actually pursue engineering.

Conclusions

Each year, The Citadel chapter of SWE hosts “Introduce a Girl to Engineering Day,” an outreach event intended to excite middle-school-aged girl scouts about engineering. Pre- and post-surveys were administered to analyze participants’ engineering attitudes. The following conclusions were made based on the results.

1. Before attending the outreach event, participants expressed several positive attitudes towards engineering, which may suggest that the group of girl scouts had already been exposed to positive engineering experiences.
2. Engagement in the events led to positive impacts on participants’ engineering attitudes, especially those related to interest in becoming and confidence to become engineers.
3. Perhaps more extensive and/or more frequent outreach events may be needed to transform participants’ positive engineering attitudes into action to pursue engineering.

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