Assessing the Efficacy of K-12 Engineering Outreach "Pick Up and Go" Kits

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Abstract

With the growing emphasis of Science, Technology, Engineering and Mathematics (STEM) education at the K-12 level, many schools are reaching out to colleges and universities to have engineering faculty and students visit their classrooms. However, engineering faculty and students may be reluctant to engage in this outreach because they do not have the time or resources to develop an appropriate activity. To address this issue "pick up and go" engineering activity outreach modules were developed, piloted and assessed in K-12 classrooms and afterschool programs. These activity modules were developed to incorporate research based best practices and principles that have been found to be successful in attracting girls to engineering and all activities were mapped to the Ohio Academic Content Standards. The modules focused on engineering design and innovation, such that the activities encouraged team work, creativity and problem solving. Scenarios were provided as part of the activities to demonstrate the social relevance of engineering. The kits contained all materials needed to facilitate the activities, a memory stick with an introductory power point presentation, complete instructions aimed at both the college student facilitator and a separate document for the K-12 teacher, evaluation forms and pre- and post- test forms. Through this project, nine kits were fully developed, piloted and assessed. These kits were facilitated to over 1200 K-12 students, primarily in grades 3 through 6. Facilitator feedback showed that the kits were easy to use and the instructions were both complete and easy to follow. The teachers felt that their students learned a great deal about engineering from these activities. The mean gain in pre- to post- test scores was found to be significantly greater than zero for all students, however the main gain for the female students was found to be higher than that of the male students. These results show that the outreach activities were effective at increasing the K-12 students' attitudes, interest and awareness towards STEM, but they were more effective for the females.

Introduction

Numerous papers and reports have been written that describe the crisis facing the United States (US) with regard to literacy in Science, Technology, Engineering and Mathematics (STEM) and the shortage of engineers in the US.[1-4] In particular, the US needs engineers to fuel economic growth, maintain global competitiveness and to solve some of the world's greatest challenges.[5-8] In a 2008 NBC.com article, Alan Boyle reports, "After a year of deliberation, an all-star team of technologists on Friday laid out their list of the 21st century's top engineering challenges — a list that lifts engineers out of their geeky stereotypes and puts them at the forefront of change. The

Grand Challenges for Engineering call for countering global warming, harnessing nuclear fusion, heading off terrorism, rebuilding cities and reverse-engineering the brain. And those are just a few of the 14 items on the to-do list."[8] This report points out the critical role that engineering and innovation plays in the US economy and in addressing critical issues of our time, something that also has been recognized by top governmental administrators, including President Obama.[5, 9, 10]

Not only does the US need more engineers, but also a more diverse engineering workforce.[11-16] The recognition for the need for more diversity in engineering is not new. In a 2001 keynote address at a symposium held at Bryn Mawr College, William Wulf, Former President of the National Academy of Engineering, makes the case that the quality of engineering is negatively impacted by the lack of diversity. He goes on to discuss that, "Without diversity, the life experiences we bring to an engineering problem are limited."[16] Unfortunately however, the field of engineering continues to lack both racial and gender diversity.[11-15, 17] Despite the fact that a majority of college graduates are women, women still remain underrepresented in the field of engineering.[18, 22-24] Numerous studies have been conducted in an effort to figure out why more students in general, but particularly females do not pursue engineering. Some research suggests that students lose interest in STEM during the middle school years and many K-12 students do not have a clear understanding about what an engineer does.[22-29] Therefore, it is critical that efforts be made to provide our youth, particularly females and underrepresented minorities, about the field of engineering and to inspire them to pursue engineering.[10, 12, 22-29]

In an effort to help increase K-12 students' exposure to engineering, many universities and professional societies have initiated a variety of outreach programs and summer camps.[30-42] Although many of these efforts are very effective at exposing K-12 students to engineering, they are not always equally effective for all populations at inspiring these students to consider engineering as a possible career path.[38] Outreach activities that promote negative stereotypes regarding engineers or the profession can be counterproductive to encouraging females to pursue engineering.[43-47] A 2008 report published by the National Academy of Engineering summarizes a two-year project that used market research in an effort to improve the public image of the engineering profession. Results of this project showed that messages emphasizing the connection between engineering, creativity, ideas and human welfare and that show engineering as a personally rewarding career are more effective in attracting students, particularly females to engineering than messages that emphasize math and science skills and the highly technical applications of engineering.[46, 47] Therefore, outreach activities that are team based, include real-world problem solving that emphasize engineering as a highly creative, helping profession and demonstrate the breadth of opportunities in the field of engineering are more effective at increasing a female's interest in engineering.[2, 16, 42, 46-50] As an example, Plant et al reported an increase in middle-school girls' interest in engineering after being exposed to a 20-minute narrative delivered by a computer-generated female agent describing the lives of female engineers and the benefits of engineering careers.[51] More recently, McCormick, et al, conducted a longitudinal study to determine if a summer camp was effective in increasing the interest and understanding of the engineering profession and in developing self-efficacy in engineering for female camp participants. Results of this study showed that this camp was successful in meeting these goals and also served as a successful recruitment tool for the host university.[38] Other research suggests that engineering projects that show the humanitarian side or social relevance of engineering have been effective at attracting and retaining females.[52-54]

Although many universities are engaged in engineering outreach, there are several barriers that make it difficult for universities to offer effective outreach to a large number of K-12 students, particularly at the lower grades. Some of these barriers include money and time, but university faculty teaching and research requirements for promotion and tenure can also serve as a disincentive to faculty to engage in K-12 outreach.[39-41, 55] Undergraduate and graduate engineering students are a great and energetic resource on college campuses and can serve as effective role models for K-12 students, but many college students do not have the resources or the time to develop engineering activities to bring into the classroom or to facilitate activities on their own campuses. Although there are numerous engineering activities on the web, the time and money required to purchase materials and to vet these activities can still be a stumbling block for both faculty and students. Other issues such as insuring the activities will effectively promote engineering to females and other underrepresented populations in engineering, ensuring they are age appropriate, and coordinating visits with schools can also make it difficult for engineering faculty and students to engage in engineering outreach. Furthermore, engineering outreach activities have the potential to be further leveraged when they are linked to K-12 academic content standards and when parents are provided with information that will empower them allow them to further engage their children in engineering.

Therefore, the primary objective of this project was to remove some of the barriers that exist for universities to engage in effective engineering outreach by developing engineering activity "pick-up and go" modules/kits that could be used for one time or on-going in school engineering outreach or as an after school engineering club. By employing researched based best practices associated with engineering messaging, it was hoped that these activities would be effective in changing the K-12 students', particularly the females', perception and attitudes about engineering.[46, 47]

Activity Development and Piloting

The target audience for activity modules/kits developed through this project was middle school girls. However, the activity modules were developed such that they were appropriate for both male and female students ranging in age from third grade to eighth grade. The activities developed for the kits focused on engineering design and innovation and incorporated some of the researched based, best practices for encouraging females in engineering as described above.[46, 47] To complement the activity modules/kits resources were developed for teachers to help them to connect activities to academic content standards. The activity instructions and supplementary materials are housed on a website so that they can be freely accessed and used by anyone wishing to engage in engineering outreach. Additionally, parent information resources were included on the website to empower the parents to continue the engineering conversation with their children. This paper will focus on the outreach activities/kits.

A majority of the outreach activities and kits for this project were developed by teams of undergraduate engineering and teacher education students with oversight from engineering faculty members and the program manager of the Diversity in Engineering Center (DEC). Educators were consulted in the early stages of the project to get feedback on desirable content, approximate length of time for the activities and how to best reach and interact with the teachers. The undergraduate students were provided with training related to best practices for engaging females in engineering.[43, 44, 46, 47] A template for the activity descriptions was created by the Dayton Regional STEM Center that incorporated some of the elements of the STEM Quality Framework.[56] The activity modules for the kits were developed to focus on innovation and the engineering design process as opposed to a series of laboratory experiments, as they were intended to pique interest in engineering and not necessarily support or teach specific academic content. Regardless, each activity was linked to specific academic content standards to assist the teachers in selecting the activity kits that were most appropriate for their classroom and to provide an opportunity for the teachers to expand the outreach activity into classroom learning if desired.[57] All of the activities were developed to be fun, team-based and hands-on, to foster creative thought and show the social relevance and everyday applications of engineering. In some cases, the student teams modified existing activities they found on the web from a variety of resources such as Teach Engineering and others were developed from scratch. [58]

Each activity kit was housed in a plastic container that could be easily carried and transported. The kit included all consumable supplies as well as reusable supplies and equipment. It was assumed that the children engaging in the activities would have common school supplies such as scissors, crayons and glue, so these were not provided in the kits. The kits also included a memory stick that contained a power point that was used to introduce the activity as well as a hard copy of the presentation with suggestions that could serve as a facilitator resource should the facilitator not have access to a projector or laptop. Most of the power point presentations developed for the activity modules introduced the children to the engineering design process and then included a video or image that was meant to present the scenario that served as the hook and basis of the activity module. Also included in the kits were hard copies of the material list (including quantities), a facilitator guide and the engineering activity description template. The electronic files for these resources were also included on the memory stick contained within the kit. The facilitator guide provided a concise summary of the activity and included hints and ideas for the facilitator whereas the main file used the template provided by the Dayton Regional

STEM Center. As such, the engineering activity description template contained far more extensive information, including a detailed listing of the academic content standards related to the activity. The kits also contained various assessment forms. These included a form for the facilitator to assess the activity with regards to clarity of instructions, kit completeness and overall perception of the activity. There was also an assessment form that the teacher filled out regarding facilitator preparedness, promptness and ability to interact with the children as well as their overall perception of the activity. Finally, the kit contained pre- and post-tests for the children participants that are described in greater detail below. All of the information and files were placed on the project website for wide distribution and access. A complete description of the kits, including materials needed, power points and other resources can be found at: https://www.udayton.edu/engineering/k-12-programs/eif_grant/index.php. The nine kits developed, piloted and assessed include:

ASSISTIVE DEVICE (Grades 6-8)
Mechanical Engineering, Human Services, Health Sciences
Pulling on a sock is difficult for people with limited hand and wrist muscle control. It is a struggle for their muscles to overcome the sock's elastic potential energy when stretched, and gravitational potential energy when lifted. The students take on a challenge of designing a solution by only using the materials available that can help people pull on their socks independently.

CRACKER CATAPULT (Grades 4-8)
Mechanical Engineering, Civil Engineering, Architecture, Construction
An earthquake in Hawaii has collapsed the only bridge leading into or out of a town. The town's people are stuck, and in need of supplies! In order to transport supplies over the collapsed bridge, the neighboring town built a catapult and is flinging materials from one side to the other! The students solve this problem by designing a way to protect supplies from being damaged as they are sent to the town in need using only the materials provided.

FILTRATION (Grades 4-7)
Mechanical Engineering, Civil Engineering
In Africa, two out of five people do not have clean water. A source for clean water would help solve these problems and improve the lives of thousands of people. The students' challenge is to design, build, and test a filtration system that could be used for removing harmful pollutants/contaminants from water.

MARBLE RAMP (Grades 4-8)
Mechanical Engineering, Transportation, Distribution & Logistics, Architecture & Construction
The students' challenge is to design a more efficient system to help flight crew members in transporting luggage straight from the airplane to the conveyor belt where passengers pick up

their belongings. The design must transfer marbles from an elevated cup (symbolizing the airplane) to a cup on a lower level (symbolizing the baggage claim area) using only provided materials and must finish in the time allotted.

SAVE MAX! (Grades 6-8)
Mechanical Engineering, Chemical Engineering, Anatomy, Geology
The students' challenge is to use supplies to create a life vest that will keep Max, the family dog who fell overboard, afloat. The vest must be able to be put on quickly and easily to save the dog. Students can only use the provided materials and must follow all time restrictions.

SAVE THE BUILDING (Grades 4-8)
Chemical Engineering, Civil Engineering, Architecture and Construction
Mount St. Helens is erupting shortly. The students' task is to create a structure that will save the surrounding building before the lava places the civilians in danger. They have around 15 minutes to complete the task and save the building from the flow of lava from the volcano.

SMOOTH OPERATOR (Grades 4-8)
Mechanical Engineering, Biomedical Engineering, Medical Care
The students' challenge is to build a surgical instrument that can safely remove an object from a goat's stomach. The design cannot hurt the goat or damage the objects. The dominoes represent the goat's stomach, so the students need to be careful not to hurt the goat by knocking over dominoes.

THREE LITTLE PIGS (Grades 5-8)
Civil Engineering, Architecture and Construction
The challenge is to build three different houses, each constructed with a material similar to what The Three Little Pigs used. Straw, stick, and brick houses, built by The Three Little Pigs, were tested for their ability to withstand the destructive force of The Big Bad Wolf's huffing and puffing. Your drinking straw, Popsicle stick, and card houses will be tested for their ability to withstand the destructive forces of a hurricane's wind, rain, and hail.

ZIP LINE (Grades 3-8)
Civil Engineering, Mechanical Engineering, Transportation, Distribution & Logistics, Human Services
A recent earthquake has collapsed a bridge, which was the only way out of an island. The islanders are running out of resources quickly, and need help. The only means of transportation remaining is the island's famous zip line, which includes a section leading from the island to a neighboring city. The students are to design and build a cradle that will safely transport one islander at a time across the zip line from the island to the neighboring city.

Although the target audience for this project was middle school aged females, a majority of the classrooms or programs where the activity kits were piloted were co-gender (an average of 50% female and 50% male across all classroom outreach events). An alternative to this approach would have been to offer a specific program that was limited to female students only or to seek out schools or classrooms that were single gender (female). The Dayton region has very few single gender classrooms. As such, targeting female only classrooms would have greatly limited the availability of wide scale piloting and facilitation. Similarly, facilitating a co-curricular afterschool program that was limited to females would have required the females to voluntarily sign-up for these programs. As such, females already inclined towards STEM would have been more likely to sign-up for this program. Therefore, co-gender classrooms were chosen for this project based on the belief that an overall greater number of females would be exposed to the engineering activities, including those students who had not expressed an interest in engineering or had previously been encouraged to consider engineering. This approach prevented the female students from self-selecting out of the engineering activities based on a preconceived notion of what engineering was. Another reason for going into a co-gender classroom was to expose male students to female role models in engineering (UD female engineering students leading the outreach) thus encouraging male recognition of and association with females in engineering.

Piloting of the kits occurred in a few different stages. The teams of undergraduate students that were developing the kits met weekly as a large group. As such, these student development teams tried out the activities on other teams of students during their normal weekly large group meeting time. Feedback and input from these sessions was used to modify and improve the activities prior to them being piloted in a school setting. Arrangements were made with the Kroc Center in Dayton, Ohio to soft pilot these activities in an afterschool program. Although the kits were developed so that essentially any undergraduate engineering student could facilitate the activity with little to no preparation, a lead student facilitator was hired to pilot the activities once a week for the eleven week Kroc Center after school program. This was done to ensure that the children participating in the program were provided with a high quality experience as the lead facilitator was chosen because of her demonstrated ability to work well with children. As such, should the activity not work out as planned, she could improvise so that the children still gained something from the experience and had fun during their after school session.

After the initial soft pilot at the Kroc Center, the activities were then open for facilitation (beta pilot) at other schools. One of the faculty members involved in the project offered students in her junior level mechanical engineering course extra credit if they facilitated an activity at an area school. Approximately 50% of the students enrolled in the course took advantage of this extra credit opportunity and facilitated an activity in a classroom. Initially, the faculty member coordinated placement of the student volunteers in the classrooms and assigned the activities that would be facilitated. However, after the initial semester, teacher requests for these activities became so high, that a student coordinator was hired to schedule visits and assign kits. Student facilitators were provided with a brief introduction to their activity via a confirmation e-mail approximately 48-72 hours prior to the time they were scheduled to facilitate. They were allowed to pick up the kits approximately 24 hours prior to their scheduled facilitation date. After facilitating the activity, students had to return the kits, turn in the feedback forms and pre- and post-tests of the children and respond to prompts on a reflection sheet.

In an effort to make the activity modules freely available to other engineering students, K-12 teachers and parents, a website was developed. The activity kit instructions, resources, material lists and other related resources are posted on this website so that they can be widely accessed by people nationwide who would like to engage in meaningful and effective outreach to middle school students. Additional resources including fun engineering websites for kids, information about engineering for parents and teachers and links to websites with additional engineering activities are also included on the website. The website is housed on the University of Dayton's website and is updated and maintained by the School of Engineering. The web address to this site is provided bove.

Activity Module Kit Assessment

Several forms of assessment were identified or developed for this project. Facilitator and teacher assessment forms were developed using a five point Likert scale. Additionally there was space on these forms for the teacher and facilitators to provide information regarding timing of the activities and demographics of the class and to provide qualitative feedback. The objective of the facilitator form was to get feedback and input on the activity kit with regards to clarity of instructions, kit completeness and overall perception of the activity. Information obtained from the feedback forms was used to modify and improve the kits. The purpose of the teacher form was to get feedback on both the facilitator and the activity. In an effort to assess the efficacy of the activity in changing the activity participants' perceptions of engineering and engineers, the AWE (Assessing Women and Men in Engineering) Pre- and Post- Upper Elementary Survey was modified slightly for visual appeal and to fit on one sheet of a double sided piece of paper and facilitated.[38, 59, 60] Data from the pre- and post-surveys was gathered for a majority of the classrooms. A statistical analysis was employed (t-test) to ascertain if the outreach activities had a statistically significant, positive impact on activity participants' perceptions of engineering.

Results and Discussion

A summary of the information obtained from the teacher feedback forms is provided in Tables 1 and 2 and a summary of the information obtained from the facilitator feedback forms is provided in Table 3. As indicated previously a five point Likert scale was used in the assessment with 5 being strongly agree and 1 being strongly disagree. Averaged values obtained from the forms are provided in Tables 1-3 with the standard deviation indicated in parenthesis. Additionally, the demographics of the student participants is also summarized in Table 1.

As can be seen from Tables 1-3, both the facilitators and teachers had a positive response to the activities and kits. The facilitators generally felt the kits were complete and the instructions were clear and easy to follow. The facilitators did not encounter any major issues with access to technology, so they were able to make use of the power point presentations included on the memory sticks provided in the kits. The teachers agreed with the facilitators that the kits had the necessary supplies required for the activity. The teachers also felt the student facilitators did a good job at facilitating the activities and interacted positively with the K-12 students, faculty and staff at the schools. Both the teachers and facilitators felt that the student participants had fun with the activities and learned a great deal about engineering.

The AWE (Assessing Women and Men in Engineering) Pre- and Post- Upper Elementary Survey was facilitated in the majority of the outreach sessions to assess the efficacy of the activity in changing the activity participants' perceptions of engineering and engineers.[60] A paired t-test was performed on the resultant pre- and post- survey data to measure the efficacy of the activities in changing the activity participants' perceptions of engineering and engineers. The data generated from this analysis is summarized in Table 4.

Table 1. Summary of Results from Teacher Feedback Forms Regarding Participant Demographics and Facilitator Effectiveness.

	Participant Demographics			Likert Scale Average Score out of 5				
Title of Activity	**# of students**	**Approx % of female students**	**Approx % of minority students**	**Facilitator(s) arrived on time**	**Facilitator(s) was well prepared**	**Facilitator(s) interacted well with my students**	**Facilitator(s) were courteous and respectful to faculty and staff in my school**	**Facilitator(s) had all necessary supplies to complete this activity**
3 Little Pigs	135	50%	33%	4.6 (0.89)	5.0 (0.00)	5.0 (0.00)	5.0 (0.00)	5.0 (0.00)
Assistive Device	144	40%	18%	5.0 (0.00)	4.8 (0.50)	4.8 (0.50)	4.8 (0.50)	5.0 (0.00)
Cracker Catapult	203	48%	9%	5.0 (0.00)	4.8 (0.41)	5.0 (0.00)	5.0 (0.00)	4.8 (0.41)
Marble Ramp	97	49%	12%	4.7 (0.58)	4.7 (0.58)	4.7 (0.58)	5.0 (0.00)	5.0 (0.00)
Save Max	10	60%	100%	5.0 (0.00)	5.0 (0.00)	5.0 (0.00)	5.0 (0.00)	5.0 (0.00)
Smooth Operator	66	47%	53%	4.0 (1.00)	5.0 (0.00)	4.3 (0.58)	5.0 (0.00)	5.0 (0.00)
Water Filtration	390	49%	24%	5.0 (0.00)	4.7 (0.47)	4.7 (0.47)	5.0 (0.00)	4.7 (0.47)
Zipline	173	48%	27%	5.0 (0.00)	5.0 (0.00)	4.9 (0.35)	5.0 (0.00)	4.9 (0.35)
Total/Average	**1239**	**48%**	**23%**	**4.8**	**4.8**	**4.8**	**4.9**	**4.9**
St Dev				**0.50**	**0.37**	**0.40**	**0.23**	**0.28**
				**number shown in parenthesis is the standard deviation*				

Table 2. Summary of Results from Teacher Feedback Forms Regarding Activities

Title of Activity	My students had fun with this activity	There was sufficient time to complete the activity	I feel my students learned a great deal about engineering design process through this activity	I feel my students learned a great deal about engineering careers through this activity	The teacher handouts will be/have been helpful	The activity connects well with what we are doing in the classroom
3 Little Pigs	4.8 (0.45)	4.4 (0.89)	4.8 (0.45)	4.4 (0.89)	5.0 (0.00)	5.0 (0.00)
Assistive Device	4.8 (0.50)	4.8 (0.50)	4.8 (0.50)	4.8 (0.50)	4.8 (0.50)	4.8 (0.50)
Cracker Catapult	5.0 (0.00)	5.0 (0.00)	5.0 (0.00)	4.7 (0.52)	4.0 (2.24)	5.0 (0.00)
Marble Ramp	4.7 (0.58)	4.7 (0.58)	4.0 (0.00)	4.0 (0.00)	4.0 (0.00)	4.7 (0.58)
Save Max	5.0 (0.00)	5.0 (0.00)	4.0 (0.00)	4.0 (0.00)	N/A	5.0 (0.00)
Smooth Operator	4.7 (0.58)	4.7 (0.58)	4.7 (0.58)	4.0 (1.00)	4.5 (0.71)	4.3 (0.58)
Water Filtration	5.0 (0.00)	4.7 (0.47)	4.7 (0.47)	4.7 (0.47)	4.3 0.94)	4.7 (0.47)
Zipline	4.9 (0.35)	4.9 (0.35)	4.8 (0.46)	4.5 (0.53)	3.8 (1.94)	4.3 (0.76)
Total/Average	**4.8**	**4.8**	**4.7**	**4.5**	**4.0**	**4.5**
St Dev	**0.37**	**0.49**	**0.53**	**0.61**	**1.78**	**0.95**

Table 3. Summary of Results from Facilitator Feedback Forms

Title of Activity	The kit had all of the necessary supplies	The activity instructions were clear and easy to follow.	The students had fun with this activity.	There was sufficient time to complete the activity.	The class room had adequate technology to use the powerpoint and any video links	I feel the students learned a great deal about engineering through this activity.	The teacher was helpful in organizing and facilitating this activity.
3 Little Pigs	5.0 (0.00)	4.3 (1.21)	4.3 (0.52)	3.2 (1.47)	4.7 (0.52)	4.7 (0.52)	5.0 (0.00)
Assistive Device	4.7 (0.58)	4.7 (0.58)	4.7 (0.58)	4.3 (0.58)	5.0 (0.00)	4.7 (0.58)	5.0 (0.00)
Cracker Catapult	4.7 (0.76)	4.6 (0.53)	4.9 (0.38)	4.7 (0.49)	4.9 (0.38)	4.7 (0.49)	4.9 (0.38)
Filtration	4.2 (1.03)	4.4 (0.52)	4.3 (0.67)	4.0 (1.05)	4.7 (0.48)	4.1 (0.99)	5.0 (0.00)
Marble Ramp	4.7 (0.58)	5.0 (0.00)	4.7 (0.58)	5.0 (0.00)	4.7 (0.58)	4.3 (0.58)	5.0 (0.00)
Save Max	4.3 (0.50)	4.8 (0.50)	4.8 (0.50)	5.0 (0.00)	4.5 (0.58)	4.8 (0.50)	4.3 (0.96)
Smooth Operator	5.0 (0.00)	4.6 (0.55)	4.6 (0.55)	4.4 (0.89)	4.0 (2.24)	4.4 (0.89)	5.0 (0.00)
Zip Line	4.7 (0.78)	4.5 (0.80)	5.0 (0.00)	4.5 (1.16)	4.9 (0.29)	4.8 (0.39)	5.0 (0.00)
Average	**4.61**	**4.50**	**4.67**	**4.33**	**4.72**	**4.57**	**4.92**
St Dev	**0.71**	**0.67**	**0.51**	**1.05**	**0.76**	**0.66**	**0.33**

Table 4. Statistical Analysis of Pre- and Post- AWE Survey Data Showing the Efficacy of the Outreach Activities in Changing the Perceptions of Engineering and Engineers.

t-Test: Paired Two Sample for Means						
	Entire Data Set		**Males**		**Females**	
	Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**
Mean	35.30	36.70	35.59	36.92	35.03	36.50
Variance	20.86	24.14	22.17	29.74	19.70	19.15
Observations	235	235	112	112	123	123
Pearson Correlation	0.64		0.66		0.62	
Hypothesized Mean Difference	0.00		0.00		0.00	
df	234		111		122	
t Stat	-5.33		-3.31		-4.25	
P(T<=t) one-tail	1.16E-07		6.30E-04		2.14E-05	
t Critical one-tail	1.65		1.66		1.66	
Descriptive Statistics (post -pre)						
Mean	1.40		1.33		1.46	
Standard Error	0.26		0.40		0.34	
Confidence Level(95.0%)	0.52		0.80		0.68	

As can be seen from Table 4, the mean gain in pre- to post- scores of all participants (M = 1.40, SD = 0.26, N = 235) was significantly greater than zero providing evidence that the outreach was effective in positively changing the participants' awareness, attitudes and interest in science and engineering. A 95% confidence interval about the mean gain in pre- to post-scores is (0.88, 1.92) representing a percent change of (1.96, 4.27). When considering only the male participants the mean gain in pre- to post scores was slightly less than that of the total population (M = 1.33, SD = 0.40, N=112) while that for the females was slightly greater than that of the total population (M= 1.46, SD = 0.34, N = 123). Therefore, the results from the pre- and post-survey show statistically significant gains in awareness, attitudes and interest in science and engineering for all populations, but greater gains for the females when compared to the males.

The activities developed through this project were piloted in over 22 area schools, impacting over 1200 K-12 students including 48% female students and 23% minority students. A majority of the schools visited served students in high-need areas and included urban, rural, suburban private and public schools. These activities made it possible for over 50 University of Dayton Students to go into area classrooms, to confidently and easily engage in engineering outreach. Student volunteers were required to submit reflection papers after their experience. Some common themes identified through these reflection papers included the fact that the engineering students were excited about their future as engineers particularly because they will be able to solve problems, improve the world and be creative and innovative in their jobs. Many of the engineering students were surprised by the creative solutions developed and brainstorming tactics employed by the children that participated in the activities. All of the engineering students were able to identify "little sparks" in some of the children that made the engineering students feel that these children might make excellent engineers someday.

Conclusions

Nine "pick up and go" engineering activity modules that can be used for one time or on-going engineering outreach were developed and piloted in mixed gender classroom and afterschool programs. The modules were developed and piloted by teams of undergraduate engineering and teacher education students with guidance from the university faculty and staff. The activities were developed to incorporate research based practices and principles that have been found to be successful in attracting girls to engineering.[46, 47] The modules focused on engineering design and innovation, such that the activities encouraged team work, creativity and problem solving. Additionally, scenarios were provided as part of the activities to demonstrate the social relevance of engineering. The pre-service teachers mapped the activity modulus to the Ohio Academic Content Standards to encourage the participants to incorporate and apply topics they have learned in their science, math and language arts classes and to serve as a resource for the classroom teacher. A website was created to house the instruction sheets for all of the activity modules developed through this project and provide additional resources to parents and teacher. The activities developed through this project were piloted in over 22 area schools, impacting over 1200 K-12 children. The efficacy of the kits were assessed using the Assessing Women and Men in Engineering (AWE) tools, through activity observation and through facilitator and teacher feedback forms. Results of the assessments showed that the activity kits developed through this grant were easy to use and complete, were well received by the children participants and that the children participants learned a great deal about engineering through these activities. Results of the pre- and post- surveys showed statistically significant gains in the participants' awareness, attitudes and interest in science and engineering for all populations, but particularly for the females.

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