

Inspiring Middle School Girls into Engineering and Technology Fields

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Introduction

According to the U.S. Bureau of Labor Statistics, 47% of the United States' workforce is female [1], although females constitute only 14% of the engineering and technology workforce [2]. As engineers continue to make some of the biggest advances of our time, the demand to achieve diversity in the engineering and technology workforce is constantly increasing [3]. Studies by STEM professionals suggest that diverse teams in engineering and technology perform better [4]. The participation of women in engineering is not only needed to analyze problems from "women's perspectives" to create innovative and optimal solutions, but their participation also makes sure that experiences, needs, and desires unique to women are not overlooked [5]. Overall, the United States has not been producing enough female engineering and technology graduates to meet its demand. The National Center of Education Statistics (NCES) reports that female students were awarded only 19.7% of the total Bachelor's degrees in engineering and engineering technology programs in the U.S. in 2015-2016 [6]. This number has never crossed 20% in the past 10 years [7]. The problem is two-fold: (1) not enough female students are pursuing engineering and technology studies, and (2) those who pursue these areas often leave early in their career.

The gender differences in entry and persistence in the area of engineering and technology that leads to the under-representation of women in these fields are due to a combination of some social and environmental factors [8, 9, 10, & 11]. Some key factors that contribute to the gender difference in entry to engineering and technology areas are gender stereotypes and discrimination, perceiving engineering as a profession for men, lack of encouragement, inaccurate information about the variety of careers available, negative beliefs about women's abilities in STEM areas, and lack of access to role models particularly female role models. An overview of these factors suggests that, to minimize the effect of the factors that discourage young girls to choose engineering and technology majors, it is important that focus be placed on the K-12 system. More specifically, the negative perceptions that girls develop at a young age should be corrected before they enter high school. Research shows that emphasizing the effort on early learning environments would make a significant impact [12]. If the gender profiling and developing the concept that females are not good in STEM can be intervened in early school years, at least there is possibility that female students might pursue careers in STEM areas in future.

Recognizing the fact that female students show less interest for engineering and technology fields, the main focus of this paper is to share the experiences and describe the ongoing year-long activities, including a two-week long intense summer camp, being organized and conducted by Savannah State University Engineering Technology faculty members to stimulate the participants' interest in engineering and technology fields. The fund for conducting the activities is supported by Engineering Information Foundation (EiF), one of whose goal is to encourage middle school-girls to pursue engineering degrees. The participants for the program were the middle school girls from Savannah-Chatham County Public School Systems (SCCPSS). The

girls were recruited from 7th grade as they will have one more year before they enter high school, plus high school training before they enter college. The paper will also share how these activities of the summer camp might have made a positive impact on their young minds.

Selection of the participants

The team conducted a proactive recruitment of talented young women, networking with local middle school STEM teachers. Applicants who are 7th graders from local middle schools were asked to fill out an application form along with a statement of interest. The requirements were minimum GPA 3.0 and scaled score of 525-740 in GMAS (level 3-4 in Math). The SCCPSS has over 60% African-American enrollment, so there was also a great potential to introduce minority female students to engineering fields, who comprise less than 2% for all engineering professionals [6]. The initial target was to recruit 15 students; however, 12 students are actually participating in all activities. Out of these 12 students, 50.00% were African American, 16.67% were Hispanic, 16.67% were Asian, and 16.67% were White female students. The authors did not collect any data of age of the participants; however, as mention before, all of them were 7th grade students.

The project personnel

The project was led by a professor from Savannah State university, who was assisted by a middle school teacher from SCCPSS. In addition to these two, there were three more faculty members from Savannah State University in the project team to lead the hands-on activities indifferent engineering areas. Out of the four faculty members from Savannah State University, two were female. It is important for young women to see a woman to take a leadership role. To serve the purpose, 60% of all the hands-on activities for the summer camp were conducted by the women members of the team. The team from Savannah State University has over 10 years of experience in STEM training for middle and high school students. They have served both as PI and Co-PI for a number of grants from ONR, DoD/ARO, AEOP, NSF, DOD, and DOE.

Description of the activities

All the activities, officially stated on May 15, 2018, took place in the engineering lab at a local middle school of the SCCPSS, Savannah, GA. The engineering lab is well-equipped with 12 workstations (12 brand new PCs and 5 laptops) and with 3D modelling software (Tinkercad), robotics, and a 3D printer.

Two sets of activities were arranged:

- (1) Activities of summer camp: hands-on and other activities on different engineering fields through a 2-week long summer camp to promote the participants' interest and expose them to various engineering and technology areas
- (2) Activities of year-long mentoring program: with an aim to increase their awareness in engineering and technology areas

Activities of summer camp

A brief overview of activities of the summer camp is listed below and the detail schedule is shown in Appendix A:

- I. Train the participants in Tinkercad 3D modelling software, VEX robotics, and electrical circuits, and bridge design.
- II. Organize a guest speaker series with female engineers
- III. Conduct sessions on early college/dual enrollment programs such as the State of Georgia's Move On When Ready (MOWR)
- IV. Schedule field trips to local industries
- V. Involve parents of the participants.

As mentioned above, the hands-on activities for the summer camp on Tinkercad 3D modelling software, VEX robotics, and electrical circuits, and bridge design was arranged to expose the participants to various engineering areas to stimulate their interest. The teacher from the middle school took the lead to develop the curriculum for the summer camp with assistance from the other team members. Two field trips to local reputable industries were arranged as a complementary activity to show the connection between the knowledge learnt in the classroom and its application in the real world [13].

In addition to the hands-on activities and the field trips, three women guest speakers were invited to talk to them about their motivations to go for engineering/technology profession and share their experiences, challenges, and preparation for these types of career. Another purpose of the women guest speaker series was to show the participants how women are successfully working in various engineering/technology professions and to introduce them to some role models they can follow.

To provide academic and career counseling including advisement and to provide information of college preparation and scholarships, the project team conducted several presentations on:

- (1) Career in the areas of Engineering and Technology
- (2) Success stories - Women in Engineering
- (3) Need for women in Engineering and Technology
- (4) Preparation for Engineering and Technology professions
- (5) How to make college life affordable - available scholarships
- (6) Early college/dual enrollment programs such as the State of Georgia's Move On When Ready (MOWR).

Finally, the team also tried to involve the parents of the participants through a session on the last of the summer camp to motivate them about their children's careers in engineering and technology fields.

Activities of year-long mentoring program

After the summer camp is over, a year-long mentoring program is underway now, which will continue till April 15, 2019. The activities include:

- I. Mentoring the participants to prepare them for the 2019 Regional Science and Engineering Fair and 2019 Savannah State University Annual Research Day.
- II. Hosting seminars and one-on-one sessions to prepare them for college life and motivate them for BS degrees in engineering and technology fields.

To form girls' team and prepare them for the 2019 Regional Science and Engineering Fair and 2019 Savannah State University Annual Research Day, a total for five monthly meetings were scheduled from September 2018 to February 2019. To motivate the girls for BS degrees in engineering and technology fields, seminars are being organized by the team; one took place in November 2018 and another will be scheduled in March 2019. Furthermore, one-on-one sessions are also being conducted with each of the twelve participants.

Challenges

The team faced several challenges at different stages of the program, some of them are highlighted below:

- (1) Recruitment was a major challenge at the beginning. Some qualified students and their parents were hesitant to commit for a 2-week long camp as they had other commitments during the summer. The target was to recruit at least fifteen girls from the local middle schools. However, the team was able to recruit thirteen students, although one of them dropped herself out due to personal reason.
- (2) Arranging the summer camp in two consecutive weeks was also a significant challenge due to the unavailability of the participants and their parents. This was resolved by arranging the camp in two separate weeks to make sure that all twelve participants can take part in both weeks' activities.
- (3) The length of the summer camp was an issue for some participants. Personal conversations with the participants revealed that some of them would preferred a week-long camp instead two weeks. It was also reflected in the performance of some of them as they become less attentive at the end of week two.
- (4) As shown in Appendix A, a session was scheduled for parents to inform them about their children's career in engineering/technology areas. However, the session was postponed owing to less interest from them and their job commitments during a working day.
- (5) As a part of the year-long mentoring program, the team is conducting monthly meetings with students during the regular schools, although the initial plan was to conduct these sessions during weekends as Saturday Workshops.

Feedback from the summer camp

At this point, the team was able to measure only the immediate impact of the summer camp. The overall impact of the program will be understood at the end of the program and more prominently, after several years from now by tracking the students' advancement in high school to see whether they are progressing towards taking college admission in engineering/technology areas.

After the grant period is over, the team plans to institutionalize the activities of the project to train young girls and motivate them for engineering and technology careers. The project team plans to share the accomplishments from the project with industry and community leaders and seek their support to conduct similar activities every year. Support will also be sought from internal funds and external grants. The team is committed to mentor at least one women's middle school group to prepare them for the Annual Regional Science and Engineering Fair and Savannah State University's Annual Research Day each year. Beyond the completion of the grant, the team will strive to maintain a mentoring relationship with the participants, invite them to join other future summer programs, and keep track of their progress towards high school graduation and college admission through email/social media.

One pre-camp survey and one post-camp survey were conducted at the beginning and the end of the summer camp, respectively, to measure the impact of the camp. Some comments from the participants when asked about whether the summer camp increased their interest in engineering/technology are listed below:

- 'Yes, because I thought that engineers just had to sit at a computer....'
- 'Yes, because the summer camp gave me more knowledge about engineering and the different fields in it'
- Yes, because I got to go behind the scenes and see how different types of engineering play a part in different businesses''
- 'I liked that there were examples of successful women engineers who came to speak to us...'
- 'Yes, because I know things about engineering that I did not know before'

Conclusion

The main focus of this paper was to share the experiences of the ongoing year-long activities of the project funded by EiF and jointly organized by Savannah State University and SCCPSS for the local middle school girls with an aim to inspire them to pursue careers in engineering and technology areas. One-on-one conversations with the participants and some of the encouraging statements, collected through a post-camp survey, revealed that activities like these might have had a positive impact on the young minds that can help to make career decision in future. Although the overall impact of the program will be understood only after two or three years from now.

To create an impact in the local community, the project team plans to institutionalize the activities of the project to train young girls and motivate them for engineering and technology careers. Support will also be sought from internal funds (College of Sciences and Technology and President's Office) and external grants. The project team plans to share the accomplishments from the project with industry and community leaders and seek their support to conduct similar activities every year. The team is committed to mentor at least one women's middle school group to prepare them for the Annual Regional Science and Engineering Fair and SSU's Annual Research Day each year. The team will also strive to maintain a mentoring relationship with the participants of the project, invite them to take part in other future summer programs, and keep track of their progress towards high school graduation and college admission through email/social media.

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Appendix A: Schedule for summer camp activities

Day/Time	7:30-8:45	8:45-10:00	10:00-11:00	11:00-12:00	12:00-1:00	1:00-2:00	2:00-3:00
Week 1							
Monday	Check-in & Breakfast	(1) kickoff of the camp (2) Pre-camp survey	Hands-on activities on VEX robotics		Lunch	Presentation: Success stories - Women in Engineering	
Tuesday	Check-in & Breakfast	Review lessons and completing tasks from previous day	Hands-on activities on VEX robotics		Lunch	Presentation: Career in the areas of Engineering and Technology	
Wednesday	Check-in & Breakfast	Field trip			Lunch	Review lessons and completing tasks from previous day	Hands-on activities on VEX robotics
Thursday	Check-in & Breakfast	Review lessons and completing tasks from previous day	Hands-on activities on Tinkercad 3D modelling and 3D printing		Lunch	Women Guest Speaker	
Friday	Check-in & Breakfast	Review lessons and completing tasks from previous day	Hands-on activities on Tinkercad 3D modelling and 3D printing		Lunch	Group Competition on VEX robotics	
Week 2							
Monday	Check-in & Breakfast	Review lessons and completing tasks from previous day	Hands-on activities on Tinkercad 3D modelling and 3D printing	Presentation: How to make college life affordable - available scholarships	Lunch	Women Guest Speaker	
Tuesday	Check-in & Breakfast	Review lessons and completing tasks from previous day	Hands-on activities on bridge design		Lunch	Group Competition on 3D modelling and printing	
Wednesday	Check-in & Breakfast	Review lessons and completing tasks from previous day	Hands-on activities on bridge design		Lunch	Presentation: Preparation for Engineering and Technology professions	Presentation: Need for women in Engineering and Technology
Thursday	Check-in & Breakfast	Review lessons and completing tasks from previous day	Hands-on activities on bridge design	Presentation: Information on MOWR (Move on When Ready) and Dual Enrollment	Lunch	Women Guest Speaker	
Friday	Check-in & Breakfast	Review lessons and completing tasks from previous day	Group Competition on bridge design		Lunch	(1) Post-camp survey (2) Certificate and plaque distribution	Parents' session