Assessing Effectiveness of K-12 Outreach Programs in Attracting Underrepresented Students to Engineering Programs: State of the Practice

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Abstract

Despite various incentives and outreach programs to promote the attraction of underrepresented K-12 students to the engineering field, engineering programs still have one of the lowest shares of women and minority students. The attraction rates of underrepresented students have not risen significantly within the past two decades. The research aims to review the current state of K-12 outreach programs and assess the effectiveness of different outreach strategies in increasing the number of women and minority students in Engineering programs. First, through a comprehensive review of the literature, we identify an extensive list of strategies for encouraging women and minority students to pursue higher education in Engineering, focusing on colleges and universities in the Southeast region. Then a holistic review of the website of these institutions was conducted to investigate various approaches of outreach programs. The collected data was compared with the gathered enrollment profile of the given institutions to find a possible relationship between changes in the enrollment rate of female students from 2016 to 2020 and the type of the investigated outreach programs. However, a clear pattern could not be found based on the domain of available data, and the need for detailed data was identified for future studies. Finally, the paper concludes with a list of recommendations to improve the impact of K-12 outreach programs to attract underrepresented students to engineering majors.

Keywords

Engineering, Underrepresented, Outreach, K-12

Introduction

Many attempts have been made to introduce engineering majors to prospective K-12 students in the United States in order to increase the number of engineering graduates and address the rising national demand for engineering professionals. Despite these outreach efforts, there is a disparity in the number of female and minority students among Engineering college students and degree holders.

The most recent report published by the National Center for Science and Engineering Statistics (NCSES) in 2018 indicated an increase in the number of females graduating from Science and Engineering (S&E) fields; however, the proportion of females still depends on the field of study: “female S&E degree holders were most prevalent in psychology, biological

sciences, and agricultural sciences and the least prevalent in computer sciences and engineering."[1] The chart provided by NCSES, shown in figure 1, illustrates the disparity of female is more noticeable in awarded undergraduate degrees. The number of Engineering degrees awarded to females suggests limited progress in a decade; whereby, there was a slight increase from 18.5% in 2008 to 22.2% in 2018. That stated, there is still an indication of a shortage in female retention in the Engineering field[1].

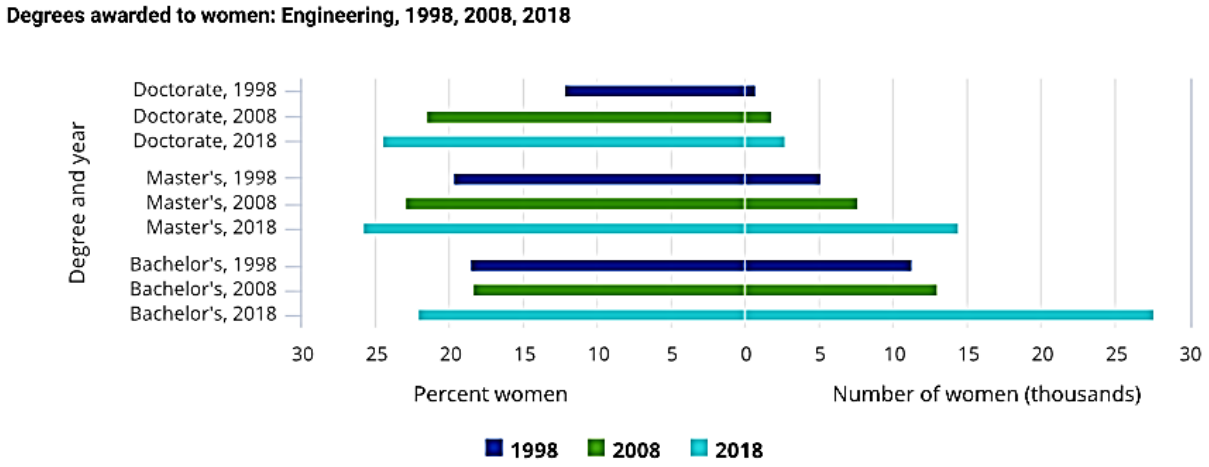

Figure 1- Engineering Degrees Awarded to Women 1998, 2008 and 2018 (Figure Source: NCSES Report 2018)[1]

This issue is not just a national concern, but other countries face the same problem. Naukkarinen and Bairosh (2020) researched college applicants to Bachelor's studies in Finland. Their study compared the applications among students' who selected Engineering and Technology as their first choice and those who selected natural science and mathematics. The researcher's results showed that studying in Engineering and Technology attracts fewer women and concluded that focusing the activities to increase women under Science, Technology, Engineering, and Math (STEM) categories is not enough, since the results are significantly different for Science and Math rather than Tech and Engineering[2].

Therefore, there is a need to focus on introducing the Engineering field to prospective undergraduate students mainly coming from K-12 schools. The importance and effectiveness of an outreach program are in providing the students the chance to learn about engineering capabilities as well as its future career opportunities.

This research sought to identify the current efforts in Southeast region colleges and universities and explore the opportunities to improve in these programs.

Literature Review

The underrepresentation of minorities and female students in STEM fields has been studied vastly in the literature[2-7]. Although outreach programs have a long history in the United States to recruit both boys and girls in Engineering majors[8], the attempts to attract females and minorities increased vigorously in the early 2000s. In the Burke and Mattis (2007) book, the authors

discussed how the communities need to prepare girls and other underrepresented groups to pursue STEM education[9]. Some of the selected studies and their findings are summarized as follows:

Kuyath and Sharer (2006) executed a National Science Foundation (NSF) funded outreach project to improve the perception of females and minorities about STEM-related courses and future career opportunities. They attempted to engage the students with fun activities and utilized high school clubs and contests to attract more underrepresented students. Their experience showed that students started to take classes in engineering topics and prepare to pursue engineering degrees[3]. Wieselmann et al. (2019) investigated the differences between young boys and girls exposed to engineering design activities. Their findings illustrate that "students will need additional practice and support engaging in open-ended engineering design challenges equitably" in pre-college preparation courses[6]. Naukkarinen and Bairosh (2020) pointed out the importance of explaining the concept and applications of Engineering and Technology to both girls and boys and communicating the valuable outcome of engaging women and other underrepresented groups for Engineering and Technology development[2].

Despite the abundance of the outreach programs, the statistics did not show significant changes in the number of enrolled and particularly graduated females and minorities from Engineering majors. Therefore, the effectiveness of these outreach programs should be assessed and evaluated by the researchers[8].

Caroll et al. 2018 categorized the listed Engineering outreach programs in past studies into three major groups based on their focus area: 1) students, 2) teachers, and 3) curriculum development. The programs focusing on students include summer camps, field trips, one-day events (presentations and hands-on activities), student competitions, and mentoring programs. The findings of their study indicated that hands-on activities for students are effective in creating an interest about the field of engineering and improves several cognitive skills. However, this type of activities could be misleading for the students due to a lack of the analytical element of Engineering. The programs focusing on K-12 teachers could enhance their understanding of engineering and the best ways to teach this knowledge to the kids[8]. The studies showed the key role of teachers in the success of outreach programs[10]. The researchers have proven the efficacy of workshops for teachers and then asked them to demonstrate the developed knowledge through teaching students in a camp right after the workshops[10, 11]. The last focus area of the outreach program is through adding courses to complement the standard K-12 curriculum and prepare the students to enter Engineering colleges. Lack of mathematic knowledge was a key reason for not joining and/or dropping out from engineering programs[12]. Besides these three focus areas, Caroll et al. (2017) indicated partnership among several parties engaged in outreach initiatives and evaluation of the programs as vital elements of successful outcomes. Collaboration between universities and school districts (in different levels of K-12 schools) is required to plan, as well as implement an outreach program with the aim to achieve its long-term goals[8].

The current study concentrated on reviewing the current outreach practices and finding evidence for their effectiveness.

Methodology

In this study, we conducted a combination of systematic literature review and online exploration of available and verifiable public records of outreach programs to identify and analyze the state of the practice of promotion activities in colleges and universities in the Southeast region. The focus of the study is limited to Engineering programs at colleges and universities which offer up to a Masters degree and are located in the Southeast region (Kentucky, Virginia, Tennessee, North Carolina, Alabama, Mississippi, Georgia, South Carolina, Florida, and Puerto Rico). A list of 58 institutions was created based on a cross-reference through the Carnegie Classification of Colleges and Universities and the Accreditation Board for Engineering and Technology (ABET) programs for the nine States and one territory listed above as Southeast region of ASEE. The ultimate goal of this study is to identify most effective outreach programs and implement those in the home institution which is one the programs offering degrees up to Masters. Therefore, the PhD granting universities were excluded from this study.

Figure 2 below depicts the process of this study. After literature review and creating the list of eligible Engineering programs, a holistic online search was conducted over the listed programs' websites. Additionally, the published records of enrollment profiles in the listed programs in two different years were collected to compare and apply as a verification tool of the effectiveness of the current outreach practices. Finally, based on the study's findings, a list of recommendations to improve the effectiveness of the current practices is suggested.

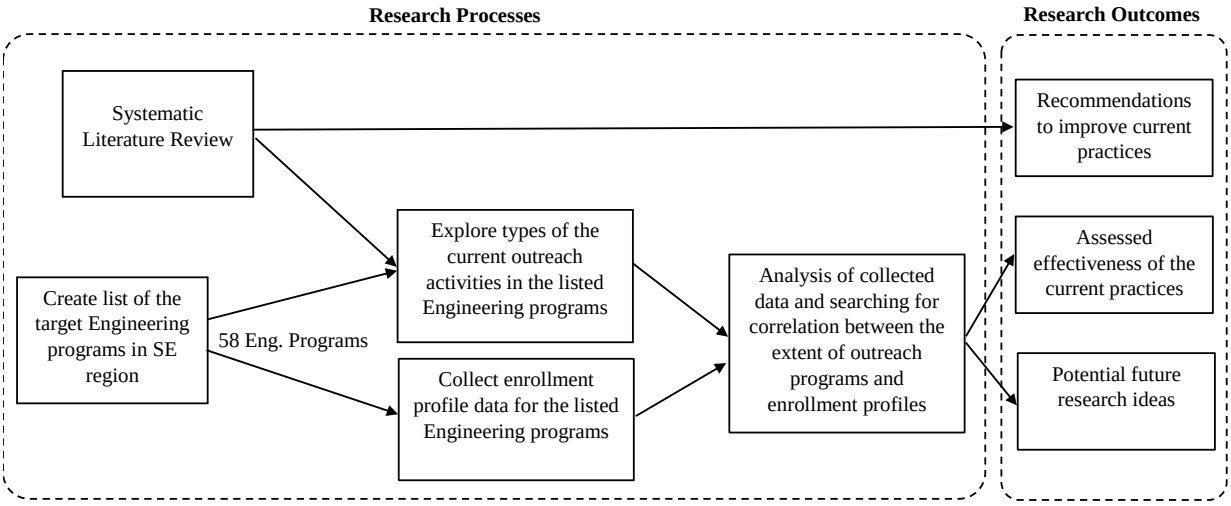

Figure 2: Research Methodology

The results and findings of the research analysis are discussed in the next section.

Discussion

After creating the list of target Engineering programs, the research team conducted a systematically designed search over the website of these programs. They looked for any published and available data about the presence of the outreach activities, type of those

programs, and evidence for particular programs with the focus on females and/or other minorities. Based on the literature review, those outreach programs that were found were categorized into four major types: Summer camps (multiple days); One-day/weekend events; Club sponsored programs (such as series of classes or competitions); and training K-12 teachers (could include a partnership with each State's Department of Education). Table 1 below represents the yielded results of this search. In 58.6% of the studied Engineering programs, evidence was found that it held at least one summer camp to attract more K-12 students (including both boys and girls). While the percentage of programs with the evidence of holding on-day or weekend events is 25.9%, only 5.2% of these Engineering programs had available documents showing club-sponsored events and programs.

Table 1: Existence and Types of the Outreach Activities in 58 Engineering Programs

Found Outreach activities		**% of Engineering Programs with evidence of having these activities**
Type of the program	Summer Camp	58.6
	One-day events	25.9
	Club sponsored programs	5.2
	Training K-12 teachers	48.3
Outreach Program Focused on Female		35.1
Outreach Programs Focused on Minorities		15.5

Another aspect that has been investigated was holding specific outreach programs for underrepresented students. There was enough evidence in 35.1% of these Engineering programs to have activities only for K-12 girls, but 15.5% of them had records of holding events for minorities only.

After completing the investigation, the enrollment profile data for each of these Engineering programs were collected from NCSES (2021) for 2016 and 2020. This data was available only for 34 out of 58 studied programs. One of these 34 programs is for women only, so it is not considered in taking the average percentage of the gender composition of the institutions. The ASEE's database for Profiles of Engineering and Engineering Technology Institutions was also checked to verify the availability of data. The percentage of total enrolled women in graduate and undergraduate levels varied between 6.6% and 35.4%. The average of the collected data is summarized in the following Table 2.

Table 2: Average Enrollment Gender-based Data in 33 Eng. Programs in SE Region

Year	# of Male (Undergrad)	# of Female (Undergrad)	Average % of Female (Undergrad)	# of Male (Grad)	# of Female (Grad)	Average % of Female (Grad)	Total Average % of Female
2016	10875	2410	18.14	740	238	24.34	18.57
2020	9735	2850	22.65	577	228	28.32	22.99

The first important finding shows that the average percentage in the undergraduate and graduate female enrollment in the studied 33 Eng. Programs of SE region during 2020 are 22.65% and 28.32% respectively which are smaller than national averages, 24.5% and 29.5% respectively[13].

Another interesting finding is that nine institutions experienced a tremendous drop in the percentage of the enrolled female from 2016 to 2020, while the average percentage increased by about 4.5%.

It was also found that in five Engineering programs that had at least three of the four studied types of categorized outreach activities, three institutions increased its percentage of the enrolled girls, one institution did not change, and the other experienced a drop in female enrollment.

Generally, an obvious pattern of following a relationship between the presence of the recorded outreach activities for females and increasing the percentage of females was not found. This concludes that there is a need for a more detailed investigation to assess the success rate of the outreach programs, particularly because the date and frequency of events impacts the assessment of the programs long-term effectiveness.

Our research team decided to continue collecting detailed data through a questionnaire survey in a future study to increase the reliability of research findings. Moreover, the analysis of the collected demographic data will be continued to assess the impact of outreach programs on minorities in future studies.

Nevertheless, the following list of recommendations is prepared based on the literature review to improve the impacts of outreach programs on traditionally underrepresented groups:

- Hold summer camps after teachers' training sessions and allow the K-12 teachers to reinstate the gained knowledge while providing the students with fun activities and improving their awareness of Engineering fields[8].
- One of the recent focus areas in outreach programs is considering the high potential of social media on K-12 students and their identity formation. It has been noticed to be very effective in having a role model and influencer in minorities, but this has not happened for females in Engineering[12].
- Providing extra-curriculum math and science courses for females and minorities in afterschool programs to prepare this group to enter Engineering fields[8, 12].
- The close partnership between researchers in the field of gender gap in STEM and outreach programs should implement continuous assessment and improvement[4].

Conclusion

Despite the presence of numerous outreach programs, the engineering schools still cannot keep up with the rising demand showing a need for formal evaluation of the current format of outreach programs in order to improve their impact.

This study investigated the current status of the outreach activities of colleges and universities with Engineering majors in the Southeast region. It did so by leveraging verifiable public records and then the authors analyzed the findings. The results did not show direct relationship between the current status of outreach activities and changes in the female enrollment rates from 2016 to 2020. Due to limitations in detailed data, the exact statistical analysis was not possible. The future possible studies include extending the data collection method to question survey of relevant administrative personnel of these institutions, and including PhD granting Engineering institution in the SE region.

Recently, ABET announced that it is considering incorporating diversity, equity, and inclusion principles into ABET's General Criteria for Accrediting Engineering Programs. The Engineering colleges need to improve recruiting more students from the underrepresented communities to meet this criterion. This will raise the need for effective and robust outreach plans to increase diverse and inclusive enrollment.

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