

# **AC 2009-252: INCREASING FEMALE ENGINEERING-DEGREE ATTAINMENT IN ELECTRICAL AND MECHANICAL ENGINEERING DEPARTMENTS**

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# Increasing Female Engineering Degree Attainment in Electrical and Mechanical Engineering Departments

## Abstract

The Engineering Equity Extension Service (EEES) project aims to increase the number of women who graduate with baccalaureate degrees in engineering, with a specific focus on the two largest engineering disciplines with the lowest female enrollments, electrical and mechanical. By bringing together expertise in gender studies, the research base on science and engineering education, and project management, EEES seeks to enhance the academic preparation, social interactions, and engineering knowledge and skills attainment of girls and women. In 2008, EEES competitively selected 14 engineering departments (4 Electrical, 10 Mechanical) and provided them access to experts in gender equity research as well as small grants for project development. The departments had proposed specific activities by which to further the goals of EEES. The departmental projects are ongoing and varied. Many chose to focus on reaching out to high school girls to encourage their interest in engineering, while others focused on providing faculty training in gender equitable teaching. Other projects focused on developing curricular or recruiting materials attractive to women and men. This paper will discuss the results and lessons learned in the various programs.

## Introduction

Despite some progress toward equality in engineering, women remain underrepresented<sup>[1]</sup>, especially in mechanical and electrical engineering, which are two of the largest disciplines. One reason for the lack of women in these fields is that more women than men change their major to a non-engineering field after beginning college<sup>[1]</sup>, and many students hold inaccurate views of engineers and engineering<sup>[2]</sup> that discourage them from entering the field. Female students especially are turned away by images of engineers as males who work alone in a laboratory<sup>[3]</sup>. Thus, it is important to disseminate accurate pictures of engineering to students of all ages.

Programs designed to expose girls to exciting work in engineering fields have had some success in increasing their awareness and accurate mental images of engineering<sup>[4]</sup>. Ryerson University saw an increase in female enrollment over the years they offered a summer camp that included active laboratory projects<sup>[4]</sup>. An extension of that project included short workshops during the school year, and although boys and girls had similar knowledge about engineering prior to the workshop, boys were far more likely than girls to indicate interest in becoming an engineer. After the workshop, both boys and girls had more knowledge of engineering and were more likely to state their interest in entering engineering. Although boys showed a small increase in this interest (46% to 51%), girls increased substantially (16% to 38%). This study suggests that providing accurate information about engineering to high school students could increase the number of engineering undergraduate students overall as well as improving the gender balance in those fields<sup>[4]</sup>.

Improving the perception of engineering alone may not increase the number of women attaining baccalaureate degrees in engineering, as students also need to have confidence in their own skills

in engineering and a network of peers and mentors who can support them through their studies and their careers<sup>[5]</sup>. Another important element, especially for girls, is having a role model to whom they can relate on a personal level, rather than a role model who is perceived as being a star in the field and thus unapproachable<sup>[3]</sup>. This indicates that undergraduate women in engineering could effectively mentor younger students because they would be able to relate to them as individuals. Finally, the assessment of one longitudinal program that brought science into elementary schools indicated that parents increased the amount of time spent talking about science with their children over the course of the program, suggesting that improved engineering and science literacy among parents could improve the image of these fields with children and possibly encourage their entry into the fields<sup>[6]</sup>.

The Engineering Equity Extension Service (EEES) aims to increase the number of women who graduate with baccalaureate degrees in engineering, with a specific focus on the two largest engineering disciplines with the lowest female enrollments, electrical and mechanical. By bringing together expertise in gender studies, the research base on science and engineering education, and project management, EEES seeks to enhance the academic preparation, social interactions, and engineering knowledge and skills attainment of girls and women. In 2008, projects at fourteen departments (10 Mechanical Engineering, 4 Electrical or Electrical and Computer Engineering) were selected from among competitively submitted proposals for improving gender equity in individual ME or EE/ECE departments. The specific plans varied across departments but many included similar activities. For example, 8 departments planned outreach activities to undergraduates or K-12 students, 6 planned to host workshops or speakers for faculty or students, and 5 focused on revising course or recruiting materials. Two departments used funds to support undergraduates' travel to conferences and two formed Society of Women Engineers (SWE) chapters. Finally, two campuses focused on mentoring undergraduate students and two sponsored social events for those students.

Each department designated one person (the Extension Agent) to work with EEES staff as well as with our external evaluator. The evaluator worked with each Extension Agent to determine the type of data to collect and also developed several surveys that were easily adaptable to the individual sites. The nature of project activities was well characterized as part of the department proposals. The evaluation also allowed for characterizing the extent or "reach" for project activities. For example, data to be collected over the spring 2009 semester include variables such as number of students or faculty attending activities, number of speakers or panelists, number of mentors and protégés, and number of materials changed and disseminated.

Departments developed projects that involved K-12 students in workshops and other engineering activities, either on the school's campus or on the university campus. Several departments were already involved in these types of outreach programs, so they used their funds to revise recruiting materials or to bring in extra speakers for the students who attended. Other departments focused on undergraduate students by reaching out to female students with social activities, mentoring programs, peer support programs, or exposure to female engineers as speakers or at conferences. Others chose to work with faculty to make them aware of gender equitable teaching techniques and how and why to incorporate them into their classrooms. Others worked to revise course content, course or curricular materials, or recruiting materials. Several departments undertook

more than one activity, for a total of 27 activities across the 14 institutions. See Table 1 for an overview of the projects undertaken.

Table 1. Number of Participating Departments Undertaking Specific Gender Equity Activities.

	Number of Departments
Outreach	8
Workshops and Speakers	6
Materials revision	5
Conference support for undergraduates	2
Forming/extending SWE chapters	2
Undergraduate mentoring	2
Sponsoring social events	2

#### Middle and High School Outreach Activities

Many of the departments developed projects aimed at encouraging middle or high school girls to try engineering in one or more workshop sessions. Most of these programs occur in the K-12 schools, although one institution held a summer camp on its campus. Two institutions are developing robotics-related outreach programs for middle or elementary age students, in an effort to increase awareness and knowledge of engineering. Two other departments used the funds to augment and reach students who participate in current activities.

The Electrical Engineering department at Kent State University, Tuscarawas is offering a robotics workshop for girls and their parents, and that workshop will also include videos about women engineers and engineering careers. The girls will also have the opportunity to join a field trip to local engineering companies. This institution will also invite girls and their parents to a yearly event in their engineering department that showcases the work of college engineering clubs. Data to be collected include number of attendees as well as opinion and attitudinal variables of the girls and their parents.

The Mechanical Engineering department at University of Toledo has partnered with a local all-girls elementary school to develop a Rocket Club that will run for 15 weeks through the spring semester. Data to be collected include the number of girls participating, as well as the number of undergraduate women working with those girls. One undergraduate woman will take a supervisory role in the project. Each session could include a lecture, discussion, observations, experiments, building, recording data, writing, graphing, a field trip, or a guest speaker. Topics will include all aspects of rocketry and principles of flight.

MiraCosta Community College held a week-long camp over the summer of 2008 for female and underrepresented minority 9<sup>th</sup> and 10<sup>th</sup> grade students. The camp was highly successful and well-attended, and the students were exposed to laboratory activities in several fields in science, technology, engineering, and math as well as presentations by local engineers and scientists. Data collected included the demographics of the students attending, as well as their impressions and attitudes toward engineering. The Agent also recorded focus group interviews with some of the students. Preliminary survey results indicate higher attraction toward a STEM career and increased self-confidence in STEM disciplinary work following the camp.

The Mechanical Engineering department at the University of Arkansas, Fort Smith used a portion of funds to communicate with junior and high school girls. Some were from the local community and attended an event that the SWE members hosted, while the others were attendees at a regional BEST Robotics lunch. Data collected included the number of girls attending, the number of undergraduate women students attending these events, and their opinions and future plans to study engineering. The SWE-hosted event attracted 23 girls and surveys indicated that several of them considered pursuing engineering following the event. One hundred and twenty BEST girls attended the lunch and heard a professional female engineer speak about her career experiences. Surveys indicated positive perceptions of that event.

The Mechanical Engineering department at Western New England College used the project grant to augment existing activities. The institution already hosts a Scholar day as well as a Girl Scouts Exploring Engineering Day, and the Extension Agent planned to collect data from the girls attending as well as review and revise recruiting materials for those events. Data collection also included plans to survey both the girls about their attitudes about engineering and the undergraduate facilitators about their experiences during the outreach activities.

#### Undergraduate Student Activities

Other institutions used all or portions of their funds to develop campus-based activities. Several used funds to support travel by female students to local conferences. Many hosted social events or panel discussions with students, faculty, and local female professional engineers who discussed their experiences and answer questions for the students. Some of these social events also focused on forming or advising SWE student chapters or Women Engineers groups. Finally, one department developed a module that was integrated into a first-year design course to show aspects of mechanical engineering that are appealing to women.

The Mechanical Engineering department at Brigham Young University used the funds to support travel to a regional SWE conference for several undergraduate women students. Data collection will include opinions about the conference for those individuals who attend as well as number of students attending presentations by those students to involve other students on campus.

The Electrical Engineering department at Colorado State University plans to provide at least partial travel support for their female students. They will also bring in women engineer speakers to discuss career choices in engineering as well as form a panel of female undergraduate students that will discuss issues and problems in their department. Data to be collected include the number of students attending the speaker events as well as their opinions of the speakers, the

number of students participating in the panel activities, and number of new students who receive travel support over prior years.

The Mechanical Engineering department at Iowa State University created a mentoring program for undergraduate students and hosted several social events. This institution also formed a student advisory board for the Women in Mechanical Engineering group to help with activities and recruiting for the department. Women students in the department were invited to a welcome picnic, a non-engineering-related social activity, and a panel discussion that included alumnae as well as local industry representatives. Data collected included the number of students participating. Several mentor pairs have met and the Extension Agent continues to raise awareness and encourage participation in the program. The welcome picnic drew 30 female students, approximately 40% of the women in the department. The “Being a Woman in Engineering” panel had 20 total student and staff attendees and they and the panel had good discussions. This institution plans to continue these programs.

The Electrical Engineering department at Jackson State University used funds to create a SWE chapter on campus and provided partial travel support for two student leaders to attend the national conference. Meetings and outreach activities will continue through spring semester. Data to be collected included the number of students joining the chapter, number of outreach and other activities hosted by the chapter, and the number of individuals reached through those activities.

The Electrical Engineering department at Texas A & M, Kingsville created a department society for female students and created a group website that links to the departmental website. Thus far they have held one staff meeting and one meeting of the students. Spring activities include an industry speaker and a high school outreach presentation. Data to be collected include number of participating students in the society, number of high school students reached and their attitudes towards engineering, and visits to and opinions of the new website.

The University of Arkansas at Fort Smith also held a lunch for current undergraduate students with local women engineers. Data collected included number of students and number of professionals attending. Six of the student leaders of the institution’s SWE chapter and 11 female professional engineers attended. The practicing engineers agreed to form an advisory board for the SWE chapter and suggested several activities that are underway.

The Mechanical Engineering department at the University of Kentucky plans to hold a luncheon activity for the female students in the department. This activity will focus on leadership in engineering for women engineers and will be based on an existing institutional program for woman leaders in many disciplines. Data to be collected include number of students attending as well as their attitudes and future plans.

The Mechanical Engineering department at Michigan Technological University used the funds to create a new module for introductory students in an existing engineering course. This “ski boot” module was designed to appeal to female students specifically, and the data collected showed higher female attendance in that module compared to two other possibilities. Specifically, 18% of the students in the new module were female, compared to 12% and 5% in the other two

modules. Further analysis will determine the attitudes and opinions of the module compared to students in the other classes.

### Faculty Development Activities

Two departments planned workshops for faculty members to educate them on using gender equitable teaching techniques.

Brigham Young University held a faculty workshop within the annual faculty retreat that will present and explain issues related to gender equity. Data collected included the number of faculty attending that session compared to others as well as their attitudes toward the information presented and their intent to incorporate the training into their teaching.

Jackson State University also held a faculty workshop that focused on gender equitable techniques to use in the classroom. This particular department does not have any female faculty, so the Extension Agent believed that because of a lack of interaction with women engineers, the male faculty might not realize that they are excluding female students. (It should be noted that some female faculty may also exclude female students, so merely HAVING female faculty may not solve the problem.) Data to be collected include topics presented in the faculty workshop as well as the number of faculty members attending.

### Material or Curricular Review and Revision Activities

Several of the institutions reviewed some of their materials as part of their projects, and a few used substantial portions of their funds to revise recruiting or curricular materials.

The Mechanical Engineering department at Pennsylvania State University used the funds for four activities. First, they changed the curriculum tracks for the major to appeal to a broader range of students. One new track (Biomedical Device Engineering, which is expected to appeal to women) was formed, 8 were renamed, 3 were combined, and 4 were removed. Thirteen pictures and captions were added to augment the new tracks and their description. In addition, they updated approximately 90% of the handbook entry for the department and included photographs and captions of female students on the departmental website and college handbook. They also developed two social networking sites, one that profiles former students and their current careers and one for current and former students to connect. The latter features 10 women out of 18 total profiles, with 3 undergraduate students, 6 BS graduates, 6 MS graduates, and 3 PhD graduates. The Agent estimates that hundreds of new and prospective students view the new departmental website and handbook, and the institution continues to track the hits to the social networking websites. Finally, they are developing a dual degree with the Bioengineering department that has a higher female enrollment with the goal of creating a critical mass of women who could encourage further female enrollment. This work is ongoing but has generated interest from female students who would like to complete the dual degree. The revised materials will be used in recruiting activities that have reached over 2000 students per year in prior years.

The University of Kentucky plans to review the recruiting materials from prior years and compare them to any changes in female enrollment. These results will inform institution-wide discussions on recruitment.

The Mechanical Engineering department at San Diego State University used the grant to construct surveys to give to Project Lead The Way (PLTW) teachers to assess their students' opinions about and interest in engineering, as well as whether they would consider attending that institution. Project Lead The Way provides middle and high school teachers with pre-engineering curricula and thus exposes students in grades 6 through 12 to engineering. The Agent will also review and update marketing materials for the institution's website based on the results of the survey. Data to be collected include the number of materials that are reviewed, updated, and disseminated. The PLTW survey is undergoing revisions based on pilot study results.

## Conclusions

Although data analysis is not complete for most campuses, preliminary results show positive changes. Women on campus joined groups and in many cases took the lead in developing projects for their groups. Younger girls who were exposed to engineering in workshops or speaker activities generally stated that they were more interested in engineering after participating. Some of the Extension Agents stated that they realized how difficult it is to change faculty behavior but also realized how important it is to engage faculty in how they can effectively reach all students. Other Extension Agents found that women were more interested in classes that included activities designed to appeal to women. These results show that with a very small amount of money and easy access to expert advice, institutions can advance gender equity within certain departments and begin the process of effecting change in the number of women receiving electrical or mechanical engineering degrees. Overall, this endeavor is showing positive progress toward the goal of increasing the number of female mechanical and electrical engineers.

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