

## **Experiences in Establishing an Outreach Program for Attracting and Retaining Minorities to Engineering**

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## **Abstract**

Since the creation of the Electrical Engineering (EE) program in our University in 2011, the student population has been steadily increasing at about 15% per year. However, although the overall student population has increased, the enrollment of minorities (female, Hispanic and African American students) has not increased at the same rate, even though our university is located in a rural area with a high African American and Hispanic population. This paper presents the experience in our department on how we have been implementing an outreach program to increase enrollment and to improve retention rates of our female and minority engineering students, as well as our efforts in collaborating with local K-12 schools for attracting students to STEM areas, and in particular to engineering.

## **Introduction**

The paper describes the faculty efforts and early results in establishing the outreach program, the particulars of the implementation, how the activities have evolved and the initial improvement in student retention. We also present the methods, mechanisms, and lessons learned during the process and how they can be helpful to others contemplating similar activities, or those anticipating the creation of a new engineering program.

## **Background**

The College of Engineering and Information Technology (CEIT) at Georgia Southern University (GSU), was founded in 2011, and it offers Electrical (EE), Mechanical (ME) and Civil (CE) engineering programs besides Computer Science (CS) and Information Technology (IT) programs. It should be noticed that GSU was just the second university in the state to offer engineering after Georgia Tech.

Since its conception, one of the goals of the College of Engineering was to increase the number of students in the engineering majors offered in the college (EE, CE, ME). Although the overall number of students in the college has been steadily increasing at a rate of 15%, this increase was not true for minority students. In particular, the EE program has been traditionally the one of the three programs with smaller number of female and Hispanic students. Because of this lack of interest in the program, in the EE department we were particularly interested in implementing short and long term methods or programs that could help in increasing the number of female and minority students. Research suggests that some effective (long-term) methods that can be used for attracting and retaining female and minorities in engineering include to generate early interest among younger students (K-12) by providing engineering experiences that use hands-on activities and organizing outreach and support events that show what people in the different engineering areas do and give a clear image of what a career in engineering is about. On the other hand, some effective (short-term) methods that can be used for attracting and retaining female and minorities in engineering include having minority and female faculty members to visit high

schools to give presentations and motivate students to go into the engineering fields, offer summer opportunities for high schools students to work with faculty, and to implement recruitment policies that identify minorities to be accepted into the engineering programs, etc.

In the next sections we describe the particular efforts that have been implemented for attracting and retaining female and minority students and the description of the activities.

### **Problem Identification**

We investigated the race and gender mix of students in traditional courses for the Electrical Engineering program in our college versus the gender mix and race of students choosing other majors such as humanities, business or arts programs [1]. In particular, four cohorts of the senior design classes were used to perform the investigation, with about a total of 120 students participating. The student population was as follows: Women (of any race) comprised about 9.3% of the total class population for these senior design course offerings, while male African-American comprised 23%, and Hispanic students comprised 5.3%. On the other hand, in humanities, business and arts programs, women comprised over 50.2%, African-American 27%, and Hispanic 2.61% of the student population. We also noticed that in the education and nursing programs female population was over 80%. These differences in student population are significant and support the concept that women are naturally drawn to careers that involve some kind of social involvement and human interaction. Based on this we concluded that female students will be more drawn to pursue engineering as a career if they see the application and emphasis of engineering careers that involve humanitarian, social, or medical applications and help solve problems in these areas.

### **Methods**

Based on the above statistics, and what we found in literature related to this topic [2-9], we tried to identify and create different activities that could generate interest among present and younger students by inviting the EE faculty to create and participate in outreach events that included hands-on activities, or to develop activities that encourage innovation, invention and creativity using science, technology, engineering and math skills. Other outreach methods included using present engineering students as mentors for younger students in high and middle school to participate in science and engineering competitions. Other kind of activities were focused for K12 teachers by the creation of professional development activities, and providing role models (female, African-American and Hispanic faculty) to increase feelings of inclusion among female and minorities engineering students.

The overall goal of the short and long term activities and outreach program generated at GSU was the creation of actions that demonstrated that engineers could be sensitive to social contexts, committed and qualified to serve their community by contributing to the solution of social problems at local, regional, national, and international levels. In the short term, we are achieving this goal through the development of a senior design that teaches engineering students how to bring technical knowledge and skill to bear on the real world problems of the less materially advantaged in order to promote development of the common good. We focus on our existing strengths namely: robotics systems, power systems, and communications, and in emerging engineering disciplines including, biomedical applications, human-robot interaction, and

intelligent vehicle control & communication. These capabilities are applied to the solution of problems for areas and people who can benefit from engineering expertise.

Four specific goals of the outreach program were defined:

- (1) Create a culture of acceptance and value of community and service activities at GSU. The goal is to create an enhanced appreciation of the value and importance of the participation of engineers in community and community service.
- (2) Increase the number of GSU engineering graduates that enter occupations that have a community or service emphasis. Although this is a long time goal, we anticipate measurable changes in enrolment patterns in the next semesters.
- (3) Increase the recruitment of women and minority students to the engineering program at GSU. As a result of new recruitment activities that emphasize service and our K-12 outreach activities, we anticipate an increase in applications from women and minority students.
- (4) Increase the number of engineering students that enter internships in community or regional service.

Some of the specific activities that were implemented related to accomplish the above goals are:

1- Outreach to K-12 students through the active engineering student chapters in our college, namely: The Society of Women in Engineering (SWE), the Institute of Electrical and Electronics Engineers (IEEE), The National Society of Black Engineers (NSBE), The Society of Manufacturing Engineers (SME) and the American Society of Mechanical Engineers (ASME).

- Engineering students, mainly female and minority, visit after-school programs, once a month, to encourage invention and creativity with STEM hands-on activities for the children.
- Engineering students, through SWE, IEEE, NSBE, SME & ASME, are also in charge of the engineering booth in the STEM, Science Olympiad and Art Festivals that take place once a year each in our campus. In these events, K-12 children and their parent visit our campus to learn about STEM fields through hands-on activities that promote creativity in the children, and stress the importance of engineering, math and physics.

2- Outreach to our engineering students.

- Residential grouping of first-year female engineering students (learning and living community). First-year female engineering students live in a residential area reserved for engineering students that provides weekly activities for engineering freshmen. Activities include motivational presentations from professional engineers (primarily female and minorities) from industries in the region; workshops for resume development; and social gathering with engineering faculty.
- Professional development activities, including field trips to industries, and invited engineers that present about the actual work that engineers do in the real world.
- Providing advising and strong support for female and minority engineering students to find co-ops, internship opportunities and study abroad programs.

3- Mentoring for Science and Engineering competition

- Senior undergraduate students are invited to participate as mentor for K-12 teams of students participating in the Lego League and First Robotics competitions
- Undergraduate students are invited to participate as judges and presenters for the STEM-Festival and Science Olympiad. Next we show some images of these activities



Fig 1. EE Students participating in the STEMfest



Fig 2. Girl Scout visiting GSU and participating in engineering focused games

### **EE capstone Design Course**

Within the engineering community it is widely believed that many of the challenges which are facing practicing engineers in the 21st century can best be met by exploiting multidisciplinary approaches. Our Senior Capstone Design Course has been established to demonstrate the value and ingenuity which can be derived from cooperative design efforts among traditional engineering disciplines.

The projects for the senior design program are suggested by the faculty, industry, and academic undergraduate research through engineering grant contests. The requirements are that the project be open-ended, multidisciplinary, and have non-engineering constraints (e.g., economic, environmental, aesthetic). The students are given a choice of 10 to 15 projects (depending upon class enrollment) and write a proposal stating their top choice. The senior design faculty team assigns two to three students to each project by taking into account the student choice and student capabilities as indicated on a resume, and assigning a multidisciplinary mix for the final

team. Gender is not a consideration in team or project assignment. Since the spring semester of 2014, the project choices have included humanitarian projects. These projects have incorporated community power projects, curriculum help for rural and inner-city schools, building design and construction of solar cell based vehicles, and engineering solutions for economic expansion. Both local and regional projects have been undertaken.

### **Evaluation and Outcomes**

Students are asked to demonstrate their robot and prepare a paper on their design, focusing on the novel aspects of using analog computation. Most of today's students have never seen the sort of analog computer that many professors used during their time as a student, so this exercise provides for them their first introduction to this concept. In their paper, students are asked to discuss the important aspects of analog computation: effectiveness, efficiency and significance. This exercise helps to crystallize the experiences of the exercise into a clear picture of analog computation. References are made to various analog circuits used in other courses to provide differentiation, integration, etc. Students finish the experience with a new tool and a new appreciation for selection of appropriate computational facilities for mobile robots. Later experiments focus on aspects of microprocessors that make them uniquely useful for tasks that analog systems are unable to accomplish.

### **Conclusions**

In this paper we have described the implementation of an outreach program that focuses on the application of short and long term actions in order to increase the number of female and minority students in particular and overall student population in our department and college in general. Through school visits, games, hands-on activities and lab experimentation, K-12 students are exposed to the fields of science and engineering. They design and build projects to accomplish a common task: to make engineering fun, interesting and at the same time learn that it can be used to solve not only technical problems but also can be used to solve problems related to social, humanistic, arts and biomedical areas. These experiences leave students with a fresh insight into the usefulness of engineering, and broadens their understanding of its application to the real world. The students who participate in these experiences are more likely to pursue an engineering carrier in the future.

The new two-semester senior project sequence has now been offered for one year. Over that time, a process of review and continuous improvement has been use and the new sequence is now consistently producing quality and successful senior projects. In fact, the last two semesters have generated several projects that could easily serve as beta prototypes for commercial products. Many factors can be attributed to this success.

First, the early identification of a project gives the students ample time to understand the problem and develop conceptual solutions. Also, requiring them to find an advisor gives them early opportunities to consult with a technical expert. Secondly, one of the major problems with the original capstone design course was that students did not take the time to truly define the problem they were trying to solve or to understand exactly what the final outcome of their work would be. Through three informal presentations to their technical advisor in the first semester, they are forced to develop a formal problem statement that includes requirements, a complete functional diagram of their proposed solution, and a list of deliverables

that they will present over the course of the second semester. By committing themselves to an incremental list of partial products, they are creating a self-regulating mechanism for keeping themselves on track. Third, the formal proposal due at the end of the first semester helps cement the faculty's expectations of their project. It also gives the students the opportunity to think through their approach and the risks associated with their project such as availability of parts, etc. Fourth, a rigorous and documented assessment of the technical merit of a student team's project allows the students to objectively assess the worthiness of their project. It has also made the level of effort more consistent between teams which had been a problem in the past.

### **Future Work**

Based on the comments received from faculty and students participating in the outreach activities, in the near future we are planning to improve these programs by:

- Increasing the availability of financial aid for prospective students from minorities to motivate enrollment
- Creation of scholarships and grants with focus to minorities, to attract high performing students
- Introduce techniques, other than standardized testing (SAT, ACT, etc.) as a measure of students potential that allows students from non-traditional educational experiences to succeed in the engineering programs
- Creation of honor courses with focus in engineering

### **References**

- [1] Georgia Southern University: Office of Strategic Research and Analysis, *Comprehensive Program Review- Enrollment*, <http://osra.georgiasouthern.edu/sra/CPRenrl/index1.cfm>, Last Accessed January, 2016.
- [2] May, Gary S.; Chubin, Daryl E.; *A Retrospective on Undergraduate Engineering Success for Underrepresented Minority Students*, Journal of Engineering Education, Vol. 92, Issue 1, pp 27-39, January 2003.
- [3] Lent, Robert W.; Lopez, Frederick G.; Sheu, Hung-Bin; Lopez Jr., Antonio M.; *Social cognitive predictors of the interests and choices of computing majors: Applicability to underrepresented students*, Journal of Vocational Behavior, Vol. 78, Issue 2, pp 184-192, April 2011
- [4] Hernandez, Paul R.; Schultz, P. Wesley; Estrada, Mica; Woodcock, Anna; Chance, Randie C., *Sustaining optimal motivation: A longitudinal analysis of interventions to broaden participation of underrepresented students in STEM*. Journal of Educational Psychology, Vol 105(1), Feb 2013, 89-107.
- [5] Hathaway, Russel S.; Sharp, Sally; Davis, Cinda-Sue; *Programmatic Efforts Affect Retention of Women in Science and Engineering*, Journal of Women and Minorities in Science and Engineering, Vol. 7, Issue 2, 2001
- [6] Bybee R., Morrow, C., *Improving Science Education: The role of Scientists*. Newsletter Forum on Education American Physics Society. Fall 1998.
- [7] Dolan E., *Education Outreach and Public Engagement, Vol. 1 of Mentoring in Academia and Industry*, Springer, 2008
- [8] Dolan E, Soots B., *Strategies for Avoiding Reinventing the Precollege Education and Outreach Wheel*. Genet 166:1601-1609, 2004
- [9] Andrews, E., Weaver, A., Hanley, D., Shamatha, J., Melton, G., *Scientist and Public Outreach: Participation, Motivation and Impediments*, Journal of Geoscience Education, Vol. 53, No.3, May 2005, pp 281-293

## **Biographical Information**

Rocio Alba-Flores was born in Mexico City, Mexico. She received a B.S. in Electrical Engineering from the National Polytechnic Institute. After graduating she worked for Fairchild Semiconductors, Mexico, as a Technical Marketing Engineer. She obtained her M.S.E.E. and Ph.D. degree from Tulane University. She worked as a visiting professor at Trinity College, Hartford, Connecticut, where she taught microprocessors, electronics and communication courses, and advised senior project designs. In the fall 2000 she joined the Electrical and Computer Engineering department of the University of Minnesota Duluth. Presently she is an associate professor in the Electrical Engineering department at Georgia Southern University. Her main research interests include robotics, control, image processing, remote sensing, digital systems, and microprocessor applications. Dr. Alba-Flores has been an IEEE member since 1978, and ASEE members since 2000. Dr. Alba-Flores has presented and published several papers in the areas of systems, robotics, control, and engineering education.