2006-532: RECRUITING UNDER-REPRESENTED MINORITIES TO ENGINEERING AND ENGINEERING TECHNOLOGY

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Recruiting Underrepresented Minorities to Engineering and Engineering Technology

Abstract

An essential component of any modern economy is a well-educated and versatile workforce able to design and produce innovative products, processes, and services[1]. The American engineering workforce demands special attention because of its importance in contributing to the nation's economy through research, design, development, and implementation of innovative products, processes, and services[1]. However, the engineering workforce in the U.S. has two significant problems: the U.S. has been unable to produce a sufficient number of domestic engineers[2], and it has been unable to produce a sufficiently diverse engineering workforce[3].

One reason for the lack of female and other underrepresented minorities in engineering is that these students show little interest in pursuing science, technology, engineering, and math (STEM) related careers while in high school[4]. If these students do not enroll in appropriate preparatory courses while in high school and if they are unaware of the career choices available to them, they will not be prepared to pursue a career in engineering and are likely to choose an alternate career path[5].

We have implemented an outreach project that increases the interest and improves the perception of traditionally underrepresented groups with respect to STEM courses in high school and STEM careers later in life. We are showing high school students that engineering can be fun, engaging, and *possible* for them through high school clubs and competitions. We will provide details of the project, and measured results of our efforts to date.

Introduction

Between 1990 and 2000, there was a 3.7% drop in the number of bachelor degrees awarded in engineering in the United States[6]. Furthermore, between the years 2002 and 2012, the Bureau of Labor Statistics expects a 3% to 9% growth in engineering occupations[7]. These statistics suggest that the U.S. will be facing a shortage of engineers in the near future. If American companies cannot recruit domestic engineers, they will go abroad to recruit engineers or they will move their engineering operations overseas[1].

The National Science Board's, *Science and Engineering Indicators*—2002 states: "The United States has long relied heavily on scientists and engineers who were born abroad, and increasingly so in the closing years of the 20th century" [1]. Clearly, the U.S. has been unable to produce a sufficient number of domestic engineers and this is a concern for many high tech companies in the U.S. In 2001, in an interview in the New York Times, Gordon Moore, cofounder of Fairchild Semiconductor and the Intel Corporation made the following comment: "We're in danger of exporting a lot of technological advantage because we're not training enough people here [in the U.S.]. Education, that's our Achilles' heel." [8]. America's economy is in jeopardy because the U.S. is unable to produce and maintain a well-educated and versatile domestic engineering workforce.

It is logical that an effective way to increase both the number of domestic engineers and the diversity of the engineering workforce is to encourage middle and high school students to pursue engineering and technically oriented professions. However, this has proven to be a difficult and complex problem, consisting of a number of distinct social challenges[9]. Not only do we face the issue of increasing students' interest, attitudes, and proficiency in math and science while they are in high school[9] so that they are prepared to enroll in engineering programs, but we must also provide information to the students, their parents, teachers, and counselors, to improve their understanding of the viability of engineering as a profession.

The goal of the *Diversity in Engineering Technology* project is to increase the number and diversity of students pursuing an engineering or engineering technology degree and to improve the regional community's understanding of engineers, engineering technologists, and the engineering professions[10]. The National Science Foundation has funded this project, which is in its third year (NSF award #0302801). In the following sections, we will describe the project and the results obtained so far.

The Project

The Engineering Technology Department at the University of North Carolina at Charlotte partnered with four community colleges and seven public school systems in the Charlotte region in the development and implementation of this project. This partnership involves a collaborative effort to recruit teachers willing to sponsor the clubs and a diverse student population to participate in the clubs and activities. To receive funding to support their club and activities, the clubs must consist of a minimum of 50% membership from students traditionally underrepresented in engineering[10]. Project monies are used to provide start-up materials to the clubs and an annual stipend of $1500 has been provided to each school for club sponsor(s).

The *Diversity in Engineering Technology* Project is executed by the project PI on the UNC Charlotte campus, a key individual at each of the community college partners and the club sponsor(s) at each of the high schools. Competition judges, mentors and support personnel have been university and community college faculty, staff and student volunteers, in addition to local members of industry and professional societies. Several student chapters of professional societies (e.g., NSBE, SWE, SHPE and IEEE) and the Lee College of Engineering Leadership Academy participants have adopted high school clubs and/or provided volunteers as part of their outreach efforts and service projects. The UNC Charlotte Office of Summer Programs and the project PI implement the summer camps, with university and community college faculty providing the discipline expertise for daily activities. Faculty are compensated at the rate of $500 per day for participating in the summer camp program.

The Engineering Technology clubs are at the heart of this project. Twenty high schools in this region have started engineering technology clubs, supporting over 400 high school students. The club activities revolve around preparing for regional competitions that require development of science, mathematics and technically related skills and are hosted by the community colleges and the university throughout the academic year[11]. Five competitions in which the clubs may participate are offered each year. In the 2004-05 academic year the competitions were:

- Trebuchets (Design, Accuracy, and Distance)
- Engineering/Engineering Technology Career Exploration: Paper and Presentation

- Engineering Science Fair: Alternative Methods to Generate Electricity
- TEAM+S Test
- Robotic Competition

The trebuchets were an exercise in mechanical engineering involving physical, mathematical and computer simulation components. We provided software (purchased through RLT.com) that allowed students to simulate the effects of design considerations prior to construction. Each club then optimized and built a team trebuchet. We then invited the clubs to the university campus to compete against other clubs in distance and accuracy. Because of the interest in physics and engineering principles generated by the competition, teachers at one of the schools were able to offer an elective course in physics (Physics II: Physics for Engineering) and enroll seven non-traditional engineering students in the class, which we view as a positive outcome directly related to this competition.

The Career Exploration Presentation met several objectives. High school students explored engineering and engineering technology careers, researched typical salaries for several disciplines, determined what level degree they would need, costs of a college education, what courses they should concentrate on in high school, and additional information relevant to the topic[11]. Students were then required to write a paper answering specific questions, and present their findings to at least two classes at their high school. High school teachers submitted their school's best papers. The five best papers were selected through a blind review process, and the authors, along with their families and teachers, were invited to the university to present their paper to several faculty members, parents, teachers, and others in the audience. A team composed of UNC Charlotte and community college partner faculty judged presentations. Every student participating in the event received a cash prize. It should be noted that all authors invited to the university were female or minority students, not by design, but because the written submission judges determined that these were the best papers[11].

The outcomes of this event were that high school students learned about engineering careers from their peers and why they need to concentrate on math and science while in high school. Parents observed that many girls and minority students were interested in engineering, and through the student presentations and our introductory remarks at the event, understood that it is in their best interests for females and minorities to pursue engineering careers.

The Engineering Science Fair focused on sources of alternative energy; i.e., non-fossil fuel based generation of electric power. Students were asked to research alternate methods for generating electricity and then, through experimentation, determine parameters such as efficiency, cost, and power output. Student projects included research into fuel cell technology, solar energy, wind energy, and river current. Competition entrants were invited to the university to demonstrate their projects and were judged by several engineering technology faculty with expertise in alternate energy. It should be noted that 80% of the entrants were female again, not by design, but by demonstrated interest.

The TEAM+S test and robotic competition is a combined, daylong event on the UNC Charlotte campus and is the only required event for those clubs receiving financial assistance from the grant[11]. Students begin the day by taking the TEAM+S Test offered by JETS – the Junior

Engineering Technical Society (http://www.jets.org). The TEAM+S Test is an open-book, open-note, team-based, college freshman-level math and science test given to high school students throughout the U.S. [11]. A team of four to eight students attempts to answer 100 multiple-choice questions (based on calculations) in 90 minutes[11]. They then answer five open-ended questions based on topics found in the first part of the test. Many high school teachers reported that their students would remain after school or work problems over the weekends to practice for this test and 44% of the students reported that they *enjoyed* preparing for the TEAM+S Test[11]. They were rewarded for this work; three of the clubs placed nationally in the TEAM+S competition.

The requirements for the robot competition are modified annually. In 2004 (the first year of the project), the competition involved "robot soccer." Dimensional specifications were given for the robot and playing field, with the object of the competition to place as many ping-pong balls in a goal while preventing a competitor from scoring in their goal[11]. In 2005, the robot competition was a "free-shot" basketball game. Again, robot and playing field dimensions were provided and students were required to design and build a robot capable of shooting a ball from a free-throw line. The team scoring the highest number of points from specified locations on the playing field won the competition. The students are allowed to use the parts from one Lego Mindstorms robot to design, build, and program their robots (the cost of each robot kit is approximately $200 and was provided by the grant). This competition has generated a significant amount of interest in engineering and excitement about the clubs. The first year, over 100 students participated. The second year, close to 250 students participated in this event.

Two one-week camps with activities representative of the civil, electrical, fire safety and mechanical fields, and developed to pique the interest of high school students are offered each summer. The students stay in the dorms, eat on campus, interact with college students (who are employed as counselors for the camps), and are engaged in engineering activities and theory for one week[12]. Although we had anticipated having to directly market to underrepresented groups, the response has been overwhelming and this strategy has not been necessary. Students enjoyed the camps so much the first year that they were offered and have returned for the second year, bringing their friends with them.

There are several reasons to host the summer camps: 1) to continue promoting engineering and engineering technology year-around, 2) to provide meaningful activities for these students in a relaxed and reassuring environment, and 3) to continue the momentum created in the clubs[12]. We also want to get these students on our campus because there is a higher probability that they will return as an engineering or engineering technology student if they visit our campus and enjoy the engineering related activities developed for them. We also believe that there is an even higher probability that they will return as an engineering or engineering technology student if they develop a relationship or bond with one or more of the professors[12]. However, it should be emphasized that the goal of the project is to increase the number of students, especially those from traditionally underrepresented groups, in engineering and engineering technology. We will therefore consider the program an unqualified success if students enroll in a two or four-year college, regardless of the institution they attend[10].

Results

Table 1 illustrates the high participation of traditionally underrepresented groups in the high school clubs compared with the demographics of the Department of Engineering Technology and the College of Engineering, which also houses Civil Engineering, Electrical and Computer Engineering and Mechanical Engineering departments, at UNC Charlotte for the 2004-2005 academic year. It is clear that if these high school students were to enroll in engineering or engineering technology programs at UNC Charlotte, the diversity of our student population would significantly improve.

Table 1: Comparison of Demographic Data UNC Charlotte and the High School Clubs

	White	African-American	Latino	Asian	Male	Female
HS Clubs	56%	23%	6%	10%	68%	32%
UNC Charlotte (ET Dept)	81.9%	11.5%	1.1%	2.6%	93.2%	6.8%
UNC Charlotte (College of Engineering)	82.6%	7.8%	2.3%	4.5%	91.4%	8.6%

In a recent survey we asked a representative sample of the high school students the following questions, and obtained the following responses.

Are You Planning to go to College?

When asked, "Are you planning to go to college?" 98.1% of the students responded: "Yes", and 1.9% responded that they were not sure (0% said "No").

Will These Students Enroll in an Engineering Program?

We then asked the students, "In what program are you planning to enroll?" Thirty-seven percent (37%) responded that they were going to enroll in an engineering program, 11% indicated they would enroll in a non-engineering, STEM (Science, Technology, Engineering and Math) program, 44.4% had not made a decision, and 7.6% were planning to enroll in a non-STEM program. Most of the students who had not decided what career they would pursue were either in 9^{th} or 10^{th} grade.

Are The Clubs Having an Impact?

If the students had decided to enroll in an engineering or engineering technology program, we asked, "If you are planning to enroll in an engineering or engineering technology program, did you make this decision ***before*** or ***after*** joining the club?" Of the students who indicated that they were planning to enroll in an engineering program, 100% of the females, 100% of the African American, and 50% of the Latino students indicated that they made this decision *after* joining the clubs. This would suggest that the clubs are having a significant impact.

Of the seniors, 40% of the female, 50% of the African American, and 50% of the Latino senior high school students surveyed have decided to enroll in an engineering or STEM program in college. This is significant because these students began participation in the project as juniors in high school. By the junior year in high school, most students have decided on a career path. After only two years of participation in the clubs and competitions, these students have decided to enroll in a STEM program.

Conclusions

To advance the interest and attitudes towards math and science of high school students, especially those who are members of groups traditionally underrepresented in the engineering and engineering technology professions, we must provide engaging, inquiry-based, hands-on activities in which they can participate[13]. One-time interventions are not enough; instead, year-round, on-going activities designed to provide a wide variety of topics and challenges will keep the students engaged and interested[13]. In addition to the activities, students must realize that there are significant commitments required to be successful in a technically oriented field. An overwhelming majority of the students have enjoyed being a part of the clubs and have enjoyed the competitions[10,11,12,13]. Most have continued as members of the club for more than one year and have brought their experience and guidance to younger, new members. Through this innovative and continually evolutionary endeavor, we are building a tradition in this region that piques the interest of high school students in engineering and engineering technology careers and educational programs.

It is encouraging to know that not only are these students working harder in math and science but they are also *asking* for new classes that focus on engineering topics. Many of the students are now preparing to enroll in engineering and related programs when they enter college, and have indicated that the clubs have positively influenced their decision. We have shown that to positively affect the career decisions of high school students, especially those who are traditionally underrepresented in the engineering, engineering technology, and engineering related professions, we must provide and support on-going, year-round activities in which the high school students can participate[13].

Plans are currently underway to expand and enhance the *Diversity in Engineering Technology* project through the creation of clubs and activities targeted towards middle school students, parents, teachers and counselors. It is anticipated that high school club students will provide mentoring and role models for the younger students, with the continued involvement of engineering and engineering technology students currently enrolled at the university or one of our community college partners. It is anticipated that, with expanded student involvement and commitment from local industries, the *Diversity in Engineering Technology* project will become a self-sustaining, fully institutionalized effort to inform and engage students at all levels and that will provide a replicable model for other regions and institutions.

Acknowledgments

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