

ENGINEERING THE FUTURE ENHANCEMENT OF PRE-ENGINEERING PROGRAMS THROUGH OUTREACH

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Abstract— *The 21st Century economy demands an educated workforce, with the greatest emphasis in science, mathematics, engineering and technology. The Pre-Engineering Instructional and Outreach Program (PrE-IOP) has been established to enlarge the future pool of qualified high-tech workers, including those who have been historically underrepresented (minorities and women). This is being accomplished through two components: the implementation of pre-engineering curriculum in middle and high schools, and a comprehensive information campaign about the rewards of science, engineering, mathematics and technology (SMET) professions. The outreach program consists of a comprehensive information campaign about the rewards of science, engineering, mathematics and technology (SMET) professions, and through various media allow the networking, coordination and distribution of information from SMET professionals and their professional associations to students, parents, teachers and guidance counselors, about the challenging and highly rewarding SMET careers and the pathways to achieve these professions.*

Index Terms $\frac{3}{4}$ K-12 education, outreach, pre-engineering, teacher education.

INTRODUCTION

Science and Math education in the United States has yet to address these entrenched challenges:

- more than half the students in grades 4-8 are taught by teachers not trained in mathematics and science;
- most students take only the minimally required math and science classes;
- girls in middle grades generally have higher grades in math and science than boys, but abandon those subjects in high school because they don't see themselves in technology careers.

The impact of these facts, nationally and in New Jersey is that the number of students selecting engineering as a major is declining. Juxtaposed to this problem is the rapidly increasing workplace demand for engineering and engineering related professionals.

The United States Department of Labor forecasts that new science, engineering, and technology jobs will increase significantly by 2010 [1], increasing over 50%. According to the National Science Board, new engineering, technology and science jobs will increase at almost four times the rate for all occupations [2]. More than 60% of new jobs will be in industries where workers will need to have at least some post secondary education.

New Jersey is among the top states in the nation of per capita scientists and engineers, and second highest in per capita wealth, according to Career Info Net/New Jersey. Among the top 25 fastest growing occupations in New Jersey for the period 1998-2008 based on industry demands are computer scientists (106% increase), computer support specialist (90%), systems analysts (82%), database administrators (56%), and engineering, mathematical and science managers (38%). (The national average percent change for occupations growth is 14%.) Among the top five highest paying occupations from the most current New Jersey data (1998) is engineering, mathematical, and science manager.

While all of these New Jersey metrics are very positive, this state is increasingly unable to maintain the needed quantity and quality, and diverse technological workforce. The number of students receiving undergraduate degrees in engineering has declined (23%) since the mid-1980. The shortage in the state can be traced back to the fact that in New Jersey fewer students choose engineering majors (6.3%) as compared to the national average of 8.4%, or other states, e.g., California at 8.5%.

To address this problem with high technology jobs in New Jersey, New Jersey Institute of Technology (NJIT) received a three-year High-Tech Workforce Excellence Grant from the New Jersey Commission on Higher Education, creating the Pre-Engineering Instructional and Outreach Program (PrE-IOP) One of the main goals of this program is to enlarge the future pool of qualified high-tech workers, including those who have been historically underrepresented (minorities and women).

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NJIT is a public research university with a specific focus on engineering, science, and technology. With an enrollment greater than 8800 students (about 3000 are graduate students), NJIT awards over 1900 degrees, covering 35 baccalaureate programs, 42 master's specialties, and 18 Ph.D. programs.

NJIT is a member of the Gateway Coalition, one of five "coalitions" of colleges and universities, created by NSF to pilot curricular innovations. In the Gateway Coalition, NJIT plays the lead role of outreach to underrepresented groups. The task of increasing the participation of underrepresented students in all of the coalition schools was assigned to NJIT because of its national reputation in pre-college programs that have led to significantly higher enrollment of minorities and women [3]. These activities include programs to recruit and retain minority, women and disabled students. African-American and Latino students comprise 26% of NJIT total full-time undergraduate enrollment with the addition of Asian-American, the percent increases to 49. NJIT enrolls two- to three-times the number of minority students as compared to many other technological universities. Women students makeup approximately 25% of its total student body, which is above the national average for the enrollment of women students in technological universities.

Traditional pre-engineering programs have concentrated on curriculum to either enrich the student's understanding of science and mathematics, or to help teachers implement pre-engineering courses and modules in their curriculum [4-6]. Other higher education institutions have reacted to these projected shortages with a proliferation of outreach programs for students and teachers and recruitment efforts with students [7-8]. It is generally accepted that good programs that provide enrichment and familiarize students with what engineers do can influence students' choice of careers. NACME (National Action Council for Minorities in Engineering) have studied students' and parents' attitudes towards and knowledge of middle school and high school mathematics and science education. In a pre- and post-design study, NACME found that outreach initiatives alone may not be enough to change many students' choices [9]. The evidence suggests that each strategy can help with the future high-tech pool, but to be most effective, both components need to be implemented.

A collaboration of the Newark College of Engineering and New Jersey Institute of Technology's Center for Pre-College Programs, the design of PrE-IOP is based on the assumption that effective science/pre-engineering secondary school curriculum (and effective teacher training), coupled with better understanding of the profession would eventually lead to significant increases in engineering enrollment. Therefore, the PrE-IOP program will be accomplished through two components:

- The implementation of pre-engineering curriculum in middle and high schools.
- A comprehensive information campaign about the rewards of science, engineering, mathematics and technology (SMET) professions.

However, if the perceptions of students and their stakeholders – teachers, guidance counselors and parents, are either negative or non-existent concerning engineering as a career, then the improved curriculum may not be effective in bringing students into an engineering career. Therefore, this paper will address the Outreach portion of the PrE-IOP Program.

Coupling of outreach with academics Curriculum development and teacher training are being used to create connections between the science and mathematics used in engineering applications in the modern workplace and standards-based science. The curriculum materials focus on teaching the pre-engineering skills of design and problem solving needed to convey the skills and knowledge required for successful admission to undergraduate engineering education programs. Academic year workshops and summer institutes are designed to familiarize the teachers with the curriculum and the associated pedagogy, with appropriate follow-up and support during the school year. These professional development programs are meant to introduce participants to technological content and resources that expand their science knowledge and their ability to access further knowledge. This infusion of engineering principles and design into existing science, math and technology classes is being coupled with awareness components that include discussions and activities illustrating who and what engineers are and what they do. Real-life engineers and engineering students are used as role models.

For example, chemical engineering is being directly related to the study of chemical principles normally introduced in high school chemistry courses. Science teachers are studying chemical engineering concepts, such as material and energy balances, batch and flow processes, and plant designed. Practicing chemical engineers and undergraduate chemical engineering students are involved in the presentation of materials. For instance, in a recent one-day program for high school science teachers, the role of females was featured in workshops focusing on different engineering fields. An undergraduate in chemical engineering collaborated with a member of the chemical engineering faculty to introduce the process of engineering and the relevance of chemical engineering to everyday life. The student provided the insights into why she chose to study chemical engineering, what her undergraduate studies involve, the required preparation and the barriers she had to overcome to pursue her career goals. This workshop approach was well received by the teachers. As a result of their experience, the teachers asked about visits to their schools by the faculty and the students.

OUTREACH PROGRAM DESCRIPTION

PrE-IOP includes the development and implementation of an **Engineering the Future** Outreach program. The Outreach program will target groups of influential adults able to affect the career decisions of youth. Educators, counselors, and parents will participate in a coordinated effort to motivate and support students to persist as they learn about the enjoyable and important work that SMET professionals perform. They will observe and hear from the practitioners about the challenging, highly rewarding job opportunities, career paths, and the social, economic and environmental impact of their work.

The outreach program will be implemented through partnerships with business/industry, educational groups, and the professional engineering, science, technology and mathematics organizations. The outreach will use state-of-the-art multi-media presentations, videos, interactive cd-roms, web-sites, and informational and career conferences. The materials will explore the SMET careers, featuring profiles of working professionals, exploring their daily work and offering advice on how to prepare for these fields, especially to underrepresented groups.

This program will form an alliance of three groups of stakeholders: educators, counselors, and parents, in order to fully inform and convert them into advocates for SMET education. It is essential that they are persuasive concerning the benefits of careers in engineering and engineering technology. Printed materials, web-sites, multi-media presentations, informational/awareness conferences and partnerships with a business/industry, pre-college education groups and the professional science, mathematics and engineering organizations will be used to inform parents, counselors, and teachers of their ability to influence career decisions of students toward engineering programs. The PrE-IOP web site will be available for the stakeholder to learn more about the engineering profession, including links to the web sites of the professional organizations.

To measure the efficacy of this program, several survey instruments are in the process of being developed. These are attitudinal surveys that will be given to all the stakeholders – educators, counselors, and parents, in addition to middle and high school students. The survey will to measure attitudes to engineering. For the high school program, this survey is comprised of five sections: 1) attitudes to engineering; 2) self assessment of engineering skills and knowledge, 3) self-confidence of academic abilities and skills, 4) academic history (i.e. courses taken in high school), and 5) a short demographic section that includes questions about their exposure to people who are engineers and their knowledge of engineering as a career [10].

SPECIFIC PROGRAMS

There are several programs that have been instituted for the Engineering the Future Outreach program. One is a high school faculty visitation program. In this program, faculty from each of the six engineering departments visit local high schools, engaging students in activities, describe the concepts of engineering, and what constitutes the various engineering fields. A PowerPoint presentation was created for this activity, and each faculty member can customize the presentation to include specific details of the department and the faculty's research areas. A generalized presentation will be downloadable from the PrE-IOP website. During several of these visits, the attitudinal survey was given to the students prior to the visit. Additional interventions will be done at several selected schools, and a post-intervention attitudinal survey will be performed.

Another outreach program was a complete revamping of NJIT's Career Day. In the past, students and teachers from local high schools would come to NJIT, and on their own visit one or more engineering departments. Each department had several different demonstrations and lectures concerning their own discipline.

In December, 2001, there were over 700 attendees at Career Day, and there were separate programs for the students and teachers. Based on our belief that high school students could not really appreciate the differences in the engineering disciplines, we decided not to have each student determine what department to visit. Instead, students were divided into six groups of about 100-120 students, and were escorted by a team of student and administrative volunteers to each of the six engineering departments. Each department had several different demonstrations, so the groups could be further broken down. This way, students were able to have an overview of all the engineering disciplines, and could make a more informed decision as to their career goals.

While these visits were underway, the teachers who accompanied the students were able to attend several mini-workshops on pre-engineering related subjects. The teachers received continuing education credits for these workshops. Subsequent reviews by both teachers and students were very positive.

Another program that will be undertaken in July, 2002, is a Women's Summer Engineering Career Exploration Program. This is an overnight engineering experience for 30 high school female students, who undertake an engineering design project as well as visit a local engineering company.

The web-site for the PrE-IOP program, whose URL is <http://www.njit.edu/PreCollege/PrE-IOP/>, is targeted to students, parents, teachers and counselors. It will include information about engineering, famous engineers,

engineering professions, a library, games, puzzles, problems, an innovation and creation center, career paths, frequently asked and answered questions, pre-college SMET programs and university undergraduate degree programs. Parents, teachers and counselors will be provided with guidance in helping students to persist with the courses needed to achieve successful and well-prepared entry into engineering and related technology programs. Materials for Spanish speaking parents will be included in the web-site. It will include a feedback mechanism for the user groups.

Existing outreach materials (on-line, printed, videos, cd-roms, etc.) about engineering and the related professions will be reviewed using focus groups of students, parents, teachers and counselors. The results will be analyzed by socio-economic, gender, age and grade-level characteristics in order to adapt and develop outreach strategies and materials for targeted marketing.

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CONCLUSION

To effectively increase the pool of students entering engineering and technology programs, a program within a major technological university was created, combining elements of both effective pre-engineering teaching modules and an outreach program oriented to the stakeholders of these potential students.

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