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Creating A K 12 Engineering Educational Outreach Center

Lawrence Genalo
Iowa State University, genalo@iastate.edu

Monica Bruning
Iowa State University

Barbara Adams
Iowa State University

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Abstract
At Iowa State University, the College of Engineering is developing a center for engineering outreach to K-12 programs in the state and selected surrounding areas. The goals for this center are: • Iowa State University's College of Engineering and its industrial partners will be a national model for K-12 partnering. • The College of Engineering will be a resource and delivery partner for every K-12 teacher in Iowa who wants to improve engineering-related content and career awareness. • The center will help to establish an early awareness of an engineering career path - especially critical to populations that are underrepresented in engineering. • The center will lead in learner-centered, hands-on, engineering activities with K-12 students.

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Comments
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Lawrence J. Genalo, Monica Bruning, Barbara Adams
Iowa State University

Introduction

At Iowa State University, the College of Engineering is developing a center for engineering outreach to K-12 programs in the state and selected surrounding areas. The goals for this center are:

- Iowa State University's College of Engineering and its industrial partners will be a national model for K-12 partnering.
- The College of Engineering will be a resource and delivery partner for every K-12 teacher in Iowa who wants to improve engineering-related content and career awareness.
- The center will help to establish an early awareness of an engineering career path - especially critical to populations that are underrepresented in engineering.
- The center will lead in learner-centered, hands-on, engineering activities with K-12 students.

Engineering Programs in Delivery

The center's objectives are being met through various programs being delivered to students in grades K-12 and their current and future teachers. In a mobile robotics program utilizing Legos and "Not Quite C" programming, an engineering course was created which provides technological literacy, hands-on learning activities, and field experiences for future teachers. "Toying With Technology[1,2]," as this program is titled, brings these hands-on activities to K-12 (primarily targeted at upper elementary students) students around the state. It provides an engineering experience for children and practice teaching experiences in a technologically oriented subject for college students.

"Investigations Through the Iowa Cable Network (ICN)" is a non-credit class, offered through distance education to high school students around the state, relating topics from high school chemistry, physics, and mathematics to applications in engineering. Each session includes a faculty-led, hands-on engineering experiment and an interactive career awareness component conducted by a current ISU engineering student. Future projects include development of for-credit engineering courses taken by high school students.

"Internet Explorers[3,4]" is a summer internship program where female high school students serve as mentors across the internet to younger girls by researching engineering topics and creating web page explanations written at the sixth grade reading level. This program started with a NSF grant and has been continued with industrial support for the

last three years.

"SEM on the Web" provides a scanning electron microscope accessed across the web and allows K-12 students to investigate the microscopic world from their own schools on a piece of equipment not found in K-12 classrooms. The Department of Materials Science and Engineering operates the microscope, provides training in its operation to undergraduate majors, and creates teams of undergraduate students and practicing K-12 teachers to create lessons for use in K-12 environments. Materials Engineering majors operate the SEM and work with Education College majors and practicing teachers who create age-appropriate lessons. The entire team is involved in the lesson's delivery. This effort is also sponsored by industry.

In addition, engineering career awareness is explored through extensive visits at home schools, on-campus, and through distance education. A K-12 database allows us to maintain a continuous connection between Iowa State's College of Engineering and K-12 students and teachers.

Engineering's Importance in K-12 Curricula

John Dewey believed that young children are "inherently active with strong impulses to investigate, to share with others what they have found out, to construct things, and to create[5]." In other words, a child is a natural engineer. Education in preschool and kindergarten helps children develop these engineering skills by providing an environment that encourages curiosity and allows for discovery through experimentation.

As the student progresses through school, concepts in mathematics and science become more complex and demand a higher level of analysis and a clearer demonstration of the relationship among logic, evidence, and acquired knowledge. The National Science Education Standards[6] call for students to be able to view science in terms of systems, practice problem-solving skills, and interpret models, data, and evidence. The study of engineering naturally allows students to develop these skills. Infusing engineering concepts in the K-12 curriculum will lead students towards a better understanding of engineering in higher education.

The President's Council of Advisors on Science and Technology Report [7] focuses on the need to build a stronger foundation for understanding mathematics and science by placing special emphasis on the improvement of elementary and secondary education. Recommended steps include the encouragement of collaborations through funding of institutions of higher education and elementary and secondary schools to provide "opportunities for hands-on experiences and application of real science as much as possible." One example of a project-based, hands-on learning course is Toying With Technology. By experiencing inquiry, problem-solving, and investigations as undergraduates, future teachers are able to pose worthwhile tasks and structure meaningful inquiry in their own K-12 classrooms.

Teachers working with a base knowledge of engineering can naturally encourage students

to consider engineering as an interesting area to explore. A national commitment to preparing teachers with an understanding of engineering concepts will have the most impact on increasing the number of students remaining engaged in technology, science, and engineering.

The Engineering Pipeline

While there is widespread support for the United States to be at the forefront of scientific and technological advancement, the disparity continues to grow between the demand for new engineers and the supply of engineering graduates. "Technical talent is the rocket fuel of the information age," remarks Harris Miller, President of Information Technological Association of America at a recent national workforce convocation hosted by the US Commerce Department. However, most reports indicate technical talent is running dangerously low – between 1990-1996 there was a 3% decline in the number of engineering degrees conferred (73,883 in 1990 and 71,388 in 1996)[8]. Public relations campaigns have appeared on many communication mediums aimed at getting young people interested in technological careers, and encouraging persistence in mathematics and science courses. Still, career aspirations of high school students do not fit the employment projections.

Current Conditions

Of the half million sophomore students who took American College Testing (ACT) PLAN test – a standardized test of educational development – 29% of the test-takers indicted an interest in science related careers, but only 14% plan careers in engineering/applied technology/computers or in natural sciences and mathematics. In terms of gender, almost as many females (28%) as males (31%) were interested in science or mathematics careers. Breaking this down further, 16% of the males and 3% of the females are interested in engineering/applied technology/computer careers[9]. Minority students do not occupy the engineering pipeline either. Minority students make of 29.7 percent of the college-age population and 33 percent of the birth rate, but only 10 percent earn engineering degrees[10]. African American freshman engineering enrollment has decreased 17% in 1998 from a high in 1992. Fortunately, there was been the growth in Latino freshman (7.2 percent) and American Indians (11.7 percent)[10]. Representation of minority students is still unacceptable in a profession whose influence will shape the 21st century.

For female students, strides have been made related to academic preparation for engineering curriculums. The average grade for girls in high school mathematics and science courses is a B (3.01) – the same as that of the boys (3.02), according to College Board[11]. Girls take 34% of the tests in AP physics and make up 42% of the AP Chemistry test-takers[11]. And in 1997 women represented 43% of those enrolling in medical schools. Similar strides for minority students have not been attained[11].

Realizing that information technology is a primary tool for engineers, it is concerning that girls make up a small percentage of computer science classes and children's software programs often reinforce gender bias and stereotypical gender roles. Girls consistently rate themselves significantly lower than boys on computer ability and boys display more self-confidence and positive attitude about computers than girls do. There is concern that computers and technology have become the new "boys club." To address this concern, an AAUW commission report will be released in early 2000, entitled "Girls in School: Technophiles or Technophobes?" The commission was charged with looking at the differences in the way girls and boys accept and use computer-based technologies and the strategies and techniques teachers can use to ensure equity in the classroom. This report will help us understand how technology shapes and changes the way we think. We need to ensure girls are not just users of technology, but creators.

Two ambient factors that have been attributed to the low interest levels in engineering are image or perception and the limited knowledge of the profession especially among primary influencers – teachers and parents. It is clear that more needs to be done to strengthen a student's preparation for life after high school and to enhance the general understanding of engineering fields. School-to-Work and other career exploration initiatives have been beneficial for exposure, but fall short in helping girls and minorities enter fields that are nontraditional for their gender or race. A recent study of fourteen School-to-Work sites found that more the 90 percent of the girls were in traditional female jobs and "boys tended to dominate-almost to the point of exclusion-in many industrial and engineering programs[12]."

Outreach and Recruitment Initiatives at Iowa State University – College of Engineering

To meet industry's demand for engineering graduates, enrollment-related goals are among the essential performance objectives stated in the College's "Blueprint for Excellence." The College expects to graduate 900 B.S. students (+200) of which 35% are women (+15%) and 8% are under-represented minority students (+5%) by 2003. To accomplish this, an outreach and recruitment function was developed under the direction of Monica Bruning beginning in January 1998.

Phase One in the development of the function included three major areas. This included expanding market share, developing and refining campus visitation programs, and advancing creative K-12 partnerships. The was accomplished by:

- Expanding market share by increasing visibility. This included 1) increased exposure at university, high school, and professional society recruiting events; 2) improving media coverage at engineering recruitment and outreach events; 3) leveraging public relations efforts in place for National Engineers Week with additional programming. The programs include: Dean's breakfasts; Tower building utilizing the telecommunication network, and inviting influential teachers/counselors of our scholarship recipients to a reception/dinner and Big 12 basketball game sponsored by the College of Engineering.
- Develop and refine campus visitation programs. More than one hundred visitation programs occur annually on campus. Our efforts were first directed to assure each

student who visited campus and indicated an interest or curiosity about engineering was connected with the Outreach/Recruitment office. Fifty student volunteers were trained to serve as tour guides or visitation hosts. A VIP visit program was developed for select students and their families. Forty special events were developed targeting various student groups. The recruitment-focused events (those for seniors in high school) yielded high enrollment rates. These events included Senior Visitation, Destination Day, Scholars Day, Preview Day, Society of Women Engineers Sleepover, and others.

- Creative programs with K-12 partners. Some examples of these programs included engineering nights, telecommunication programming into schools, Engineering 01 for pre-schoolers, and collaborations with teachers and engineering faculty.

An infrastructure to support the evolving outreach and recruitment function was developed. The major components included: publication development (print and electronic), integrated communication plan including mail, electronic and telephone mediums, database/software, operating systems, staff training, market and program analysis with on-going strategic planning. The following describes each component in more depth.

- Publication development – electronic and print communications were developed. This included publications for segmented markets (women, middle school, minority students and others) and electronic communications which reinforced messages in the print medium. One example of an electronic communication is Engineers On-line. This website is maintained by current engineering students and designed for engineering students who want to learn more about the engineering profession, Iowa State engineering programs, or just general enrollment information like what residence hall should I live in.
- Integrated communication plan – various communication plans were developed for specific market segments (middle school, year in high school, female, minority, out-of-state or Iowa resident). For high school juniors and seniors, the communication plan complemented the robust university communication plan. At strategic times in the recruiting cycle, student callers and electronic ambassadors were trained and contacted targeted students or parents for specific purposes. This could include a follow-up call after scholarship or financial aid notices were mailed, or the receipt of an invitation to a special event, or a congratulatory call.
- Database/software – a concentrated effort was made to collect the names of all students who visited campus or participated in science or math-related outreach activities. These names were entered into a database that was developed to communicate with and track students through their secondary education years. Naturally, our intent is to encourage them to consider engineering as a career choice and Iowa State as a place to pursue their goals.
- Operating systems and staff training – the outreach and recruitment office was a new function, therefore all systems and processes needed to be developed. These included response systems, information distribution schemes, phone and college visit protocol, and developing an office culture, to name a few.

- Market analysis was conducted to determine recruitment and outreach strategies. Evaluation practices were also developed to measure program effectiveness and impact over time.

At the end of the 1998-99 academic year, 12,000 students, parents or teachers participated in 170 outreach and recruitment activities throughout the academic year. The prospect file contained 8,700 prospective student names and 600 friends of the College (teachers, alumni, and advisors). Our tele-counseling campaign reached 2200 applicants. About seventy percent of the communication plan had been implemented and fall enrollment surpassed expectations. Ten percent more freshmen enrolled including 11% more women and 51% more minority students.

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LAWRENCE J. GENALO
is an Associate Professor of Materials Science and Engineering at Iowa State University. He also serves as the Academic Director for the College of Engineering's K-12 Outreach efforts. He received a Ph. D. in Applied Mathematics with Systems Engineering emphasis in 1977, served as Chair for Freshman Programs and DELOS Divisions, and was nominated as K-12 Outreach liaison between IEEE and ASEE.

MONICA BRUNING
is ISU's College of Engineering Coordinator for Outreach and Recruitment. She received a B.S. degree in Education from North Dakota State in 1982 and a M.S. in Public Administration from the University of

Colorado in 1990. She was Director of Admissions for thirteen years at colleges in Colorado and Montana and has served on state, regional, and national advisory boards for college admissions organizations.

BARBARA ADAMS
is a Teacher-In-Residence at Iowa State University. She received a B.S. degree in Education from the University of Nebraska in 1979 and a M.S. in Effective Teaching, Learning, and Leadership from Drake University in 1998. She has taught in for 20 years in K-8 classrooms, received an Excellence in Education Award, and is a member of the Woodrow Wilson National Science Foundation Leadership Program.