

## A Pipeline to Recruit Women Into Engineering

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Women constituted only 17% of those awarded bachelor degrees in engineering in 1995<sup>1</sup>, a slight increase (16%) from the previous year<sup>2</sup>. The future does not seem much brighter, either. In 1990, senior males in public high schools were more than three times as likely to choose a career in science, math or engineering than women<sup>3</sup>. Interest in engineering careers among college freshmen in 1995 reached a 20-year low, with only 2% of the women planning to enter engineering majors<sup>4</sup>, a percentage that remained constant in 1996<sup>5</sup>. Minority women are the least represented in engineering, making up only 4.8% of the 1995-96 freshman class<sup>6</sup> and receiving only 2.2 percent of the Bachelor's degrees in engineering in 1994<sup>7</sup>. The underrepresentation of women and minorities in engineering is particularly disturbing when one considers the shifting demographics in the workforce:

By the year 2000, economic expansion will create up to 18 million new jobs, but the number of young job seekers will decline due to a shift in birth rates. Reflecting changes in racial and ethnic populations, the entry rate of blacks, Hispanics, Asians and Pacific Islanders and American Indians and Alaska Natives into the workforce will be higher than for whites. Women of all racial and ethnic groups will be the major source of new entrants into the labor force, comprising 47 percent of the total workforce by 2000, compared to 45 percent in 1988. Half of women in the workforce will be between 25 and 44. Between 1988 and the year 2000, white men will comprise only 25 percent of the net growth of the labor force. Occupations most likely to grow include service, professional, technical, sales and executive and management positions<sup>8</sup>.

In order to maintain the necessary supply of engineers in the U.S., women must be recruited into engineering careers in greater numbers. Furthermore, in order to ensure that engineering problems are approached from a variety of angles, women, and other "non-traditional" engineers must be sought. Research suggests that the crucial intervention point for encouraging girls to pursue math- and science-related fields such as engineering is during middle school.

As early as the seventh grade, boys plan to study more math than girls do<sup>9</sup>. However, intervening in middle school, while necessary, is certainly not sufficient. One study found an overall decline

in both male and female students' liking and enjoyment of math from sixth to twelfth grade. Students reported that math became more difficult, that they received less support from parents, teachers and peers for studying math, and that math became more anxiety provoking over time. Female students reported that math was more difficult than did male students, and females rated themselves as more anxious in quantitative situations than males, even though their mathematical ability was approximately equal<sup>10</sup>. Once in high school, the girls saw math as less useful than boys did<sup>11</sup>, and valued math less than boys did<sup>12</sup>.

Despite all the obstacles, a sizable number of female high school students plan on careers in science, math or engineering. However, roughly 34 to 40 percent of high school graduates change their minds about pursuing these fields at or before college enrollment, constituting the biggest "leak" in the pipeline producing these professionals<sup>13</sup>. This literature points to a need for a systematic recruitment program, beginning at, or before, middle school, and continuing through high school, up to, and even beyond, college enrollment. The Women in Applied Science and Engineering (WISE) Program, housed in the College of Engineering and Applied Sciences (CEAS), at Arizona State University has made strides to develop such a recruitment pipeline to encourage young women to pursue careers in engineering and construction. Following the literature, the WISE Program has five major outreach components: pre-middle school; middle school; high school; transition to college; and pre-college teachers/counselors. Each of the components are described below.

### Pre-middle School

The WISE Program has two major programs for elementary school girls. First, the WISE Program participates in Take Your Daughter To Work Day. WISE offers hands-on engineering activities for girls visiting the university, and for girls visiting local industry, such as Motorola. During the afternoon, the girls hear a little about what engineering is, then they participate in "mini-labs", such as building a marshmallow and straw structure that must stand 2 meters high for 15 seconds. Prior to the marshmallow activity, the girls see a clip from the movie Apollo 13 where the engineers at NASA are trying to make a square filter fit a round hole using only the material available to the astronauts.

Second, the WISE Program collaborates with the Arizona Cactus Pine Girl Scouts for various activities. In September, WISE hosted a table during the Girl Scout "Math and Science Mania" event and demonstrated digital technology to about 1,000 grade school girls. The girls were able to use a digital camera to take their picture, see it on the computer, and print it out. In the process they heard about this technology, and the roles engineers play in making it happen. Also, WISE designed and facilitated an engineering program for the local Girl Scout Day Camp, designed for three age groups: 2nd-3rd grade, 4th-6th grade, and 7th-8th grade. During the

three-week camp, WISE Staff met with each age group for 45 minutes daily. Each day the girls participated in hands-on science and engineering activities and learned about women in these fields.

The simple engineering activities utilized during these events are not intended to teach the girls engineering content, but instead demonstrate some simple engineering principles. The activities are designed to produce a positive affective response to engineering so that the girls will be open to "deeper" learning experiences in the future. These events are generally low-cost, requiring only minimal supplies and staff effort. In the case of the Girl Scout Day Camp, the salaries for engineering students and a WISE program coordinator were paid for by the Girl Scouts. Aside from the Day Camp, the activities are repeated annually.

### Middle School

In addition to the above activities, which do involve middle-school aged girls, WISE hosts two major middle school programs. First, WISE TEAMS (Teaming Engineering Advocates with Middle School Students) brings middle school girls to ASU for three-days of hands-on engineering activities, including exploring the internet, building and launching their own rockets, using batik to demonstrate the doping process used with semiconductors, and bioengineering-based physiological measurements pertaining to the cardiovascular and musculoskeletal systems, including using virtual reality to look at muscle movement. In addition to the engineering labs, the girls participated in physical team-building exercises designed to emphasize the team-oriented approach to engineering. The participants were able to get to know one-another through a number of ice breaker-type exercises.

TEAMS was held for the first time in June, 1996, and hosted 38 participants, 31% of whom were minorities. Participant evaluations were extremely positive, and a pre/post questionnaire including the Math/Science Interest Inventory<sup>14</sup> and the Mathematics Self-Efficacy Scale<sup>15</sup> indicated that the girls were more interested in math and science, and much more confident in their math abilities, upon completion of the program. In 1996 TEAMS was funded by a one-time Seized Asset Community Action (SACA) grant through the City of Tempe. TEAMS will be funded by Intel Corporation in 1997.

In November, 1997, WISE will co-sponsor "Explorathon '97" with the Scottsdale branch of the American Association of University Women (AAUW). This day-long event brings girls from middle and high school, along with their parents, teachers, and counselors, to hear from local professional women in engineering, science, and math fields. In the past, this event has been

held at a local community college, however, the move to ASU will give the girls and their parents an opportunity to experience the university atmosphere, which can be overwhelming, in a positive, non-threatening manner. In the past, this event has hosted 200 girls. It is hoped that this number will double in 1997. This event is sponsored by local industry, including Intel Corporation.

The middle school programs begin to introduce more career-oriented information about engineering, but are still focused on eliciting a positive affective response to engineering, which will help to keep them open to learning more about engineering in the future. Additionally, by showing girls that math and science can be used to solve real-world problems and help people, these programs are designed to increase the girls' interest in math and science, and encourage them to enroll in higher-level math and science courses during middle and high school. Finally, these programs aim to dispel myths that girls are not good at math and science, and increase participants' confidence in their abilities to pursue engineering careers.

### High School

In addition to Explorathon, which includes high school students, WISE is involved in two major efforts at the high school level. First, WISE cooperates with the College of Engineering and Applied Sciences' Recruitment office so that each time a representative from the College visits a high school, a representative from WISE attends as well. By including female engineering students in the visits, WISE is providing role models for both male and female high school students, again disconfirming the myth that only men can do engineering. Also, the students present information about the WISE Program and its activities, recruiting participants for our high school outreach program and conveying the message that women are welcome and wanted in engineering at ASU.

WISE-Up, to the choices for women in engineering and technology, has been a recruiting staple for the WISE Program since its inception in 1993. Over 200 high school girls and teachers have participated in WISE-Up, 35% of which have been minorities. In the past, WISE-Up has consisted of three days of hands-on engineering labs, similar to the TEAMS format described above. Two sessions of WISE-Up, accommodating up to 50 girls in each, are offered each summer. The WISE-Up labs are modified or new each year to accommodate repeat-participants. In the past, labs have included Aerospace Engineering, Bioengineering, Computer Science, Construction Management, Environmental Engineering, Electron Microscopy, Electrical Engineering, Industrial Engineering, and Materials Science Engineering. For further information about these labs, please see Blaisdell and Anderson-Rowland's paper, WISE-Up: A Foundation

Coalition Effort to Recruit Women into Engineering, in the 1997 WEPAN/NAMEPA Conference Proceedings. In 1997, WISE-Up will consist of two week-long residential camps. WISE-Up is funded by a grant through the NSF Foundation Coalition.

Participants have consistently given the WISE-Up program positive evaluations. Pre/post questionnaires including the Academic Milestones Self-Efficacy Scales<sup>16</sup> indicates that upon completion of the program, the participants were more confident in their abilities to complete an engineering college major. A comparison of pre and post-program major plans revealed that participants planning majors in engineering fields increased by nearly 64 percent. Perhaps most impressive for a recruitment program, 42.9 percent of the 1994 participants and 60 percent of the 1995 participants who are now of college age are currently enrolled in engineering at ASU.

The outreach programs for high school students are designed to give girls more concrete information about what engineers do and what careers and educational opportunities exist for them in engineering. As with the middle school programs, the high school programs are also aimed at increasing girls' interest in engineering, increasing their confidence in their ability to pursue engineering, and encouraging girls to enroll in higher-level math and science courses.

#### Transition to College

At the end of their freshman year, significantly less women than men actually declare a major in scientific areas, despite the fact that they are equally well prepared for a scientific major by way of aptitude and academic background in science and math<sup>17</sup>. To address this issue, and to continue the recruitment pipeline through the transition into higher education, WISE offers two major outreach programs: Engineering for the Undecided and WISE Move.

Like most universities, ASU has a sizable population of undecided students. At ASU these students are housed in the College of Liberal Arts and Sciences, and are often never encouraged to enroll in engineering courses. In order to attract some of these students, particularly women students, who tend to make decisions about engineering later in their education, but expect to find out if engineering is right for them in their first semester of college engineering<sup>18,19</sup>, a course entitled "Engineering for the Undecided" was developed. This course is open to both men and women, but is marketed to female undecided and first year engineering students, through letters and fliers mailed to their homes. The course consists of information about how to choose a major/career, engineering career information and lab tours/activities, inter-gender communication, sexual harassment, and finding a mentor. Students successfully completing the

course receive two (non-technical) elective credits. The course has been offered for three years, but has been revised significantly over this time, precluding follow-up data for its present form.

WISE also offers a half-day transfer program for women in community colleges interested in transferring into engineering majors. This program, entitled "WISE Move", is described in detail in the 1996 ASEE Conference Proceedings (session 1692) paper "A Theoretical Basis for Recruitment and Retention Interventions for Women in Engineering".

The transition to college programs described here are designed to "plug the leak" of women students, already prepared to enter engineering, who are facing obstacles for pursuing engineering. Of course, a significant aspect of this recruitment effort include the WISE Program's retention effort, which is described in detail in the 1996 FIE Conference Proceedings (paper 7d4.3) paper "Re-Engineering Engineering Education to Retain Women". These retention efforts, including a center for women to study and meet in, are, in themselves, recruitment tools.

#### Pre-college Teachers and Counselors

While WISE is involved with many outreach programs to give pre-college young women contact with engineering, it is recognized that teachers and counselors have much more contact with these women. To tap this important resource, WISE has begun efforts to both include more teachers and counselors in existing programs, such as WISE-Up and Explorathon, and to create new programs to train teachers and counselors about engineering. For example, in conjunction with the Explorathon '97 program, WISE is offering the Arizona Guidance Counselor Training Initiative (AGCTI), sponsored by Intel Corporation, which will bring middle and high school counselors to a one-day training on how to encourage young women to enter engineering and related fields. After the program, participants may submit proposals for industry funding raised by the AGCTI to hold outreach activities on their own campuses. By providing training directly to teachers and counselors, WISE's recruitment efforts will be greatly multiplied.

#### Implications for Other Programs

WISE learned many valuable lessons throughout the development and implementation of these programs. First, it is important to start small. When the idea of WISE-Up was first discussed, WISE was a new program itself. Conducting a full-blown engineering camp was daunting. However, putting together three days of hands-on activities seemed within reach. WISE-Up has grown every year, but its modest beginnings enabled the WISE staff to get started and learn through the process. Second, listen to the students. Our female engineering students give us an abundance of information about when and how to reach girls. We were surprised to learn that

many women make a decision to enter engineering while in community college, leading us to increase our outreach efforts for this population. Climate and recruitment surveys for women and men students in engineering aid in the collection of this information. (For more information on Climate surveys see "Foundation Coalition Effort to Improve Retention of Women in Engineering at Arizona State University" in the ASEE Proceedings: 1994 Centennial Meeting of the Gulf-Southwest Section of ASEE, pp. 436-439.) Third, collaborations are crucial. Look for interested parties everywhere -- active grant writers, visiting professors, community agencies, local industry, community colleges, school districts, etc. WISE has developed many new initiatives in conjunction with such collaborators, and of course, is dependent on the funding these partnerships often generate. Finally, evaluations and tracking are imperative, both for the improvement of programs and to document that the programs are making a significant impact on the recruitment of women into engineering.

### Conclusion

WISE's recruitment programs are designed to feed into one another. A nine year old girl might attend both the Take Your Daughter to Work Day activities and the Girl Scout Math and Science Mania Day, then the next year participate in WISE TEAMS. Once in high school, she can attend WISE-Up, and then even take the Engineering for the Undecided course. The outreach activities provide a supportive pipeline which young women can follow on their way to becoming engineers. Early research found these direct recruitment approaches have been found to be particularly effective with women<sup>20</sup>, and they have made an impact at Arizona State University.

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