EXPANDING THE PIPELINE: THE CHALLENGES OF PRE-COLLEGE PREPARATION

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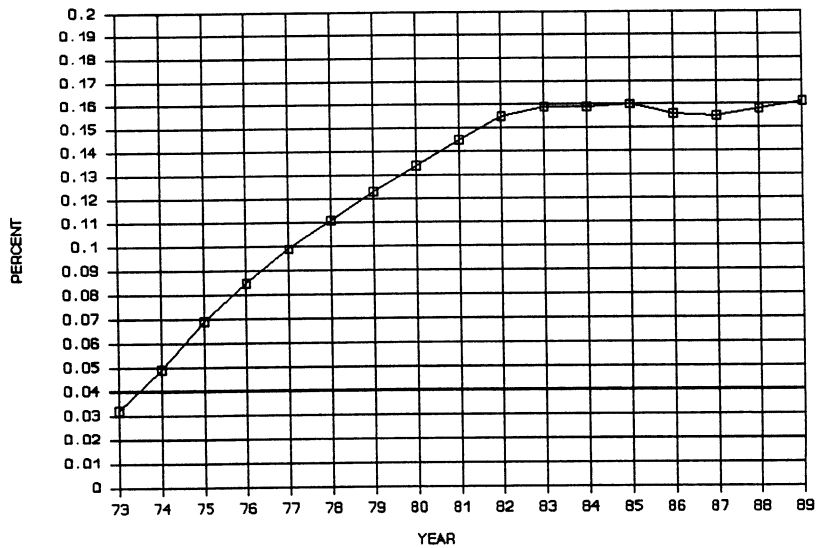
In 1971, only 1% of the engineers in this country were women. Due to the dwindling enrollments in engineering colleges and concerns of several large corporations about future "manpower" projections, efforts were mounted during the seventies to enhance the image of the engineer as a professional and to communicate opportunities to high school students, especially women and minorities. Between 1973 and 1982 the numbers of women enrolled in undergraduate programs in engineering increased more than ten-fold from 6,064 to 62,328.

Believing that the barriers for women in engineering had been overcome, universities and corporations alike focused their energies on enrolling and

Women in Engineering
Percent Undergraduates in U.S.



graduating more ethnic minorities. The external funding of programs for women was greatly reduced and scholarships for became virtually non-existent. Without financial support, many universities were unable to continue their efforts.

In 1982, the women's enrollment curve began to flatten and the numbers of women enrolled in engineering has remained level, at 15% to 16% of the total.

According to the recently published report of the Task Force on Women, Minorities, and the Handicapped in Science and Technology, interest in engineering for all students has dropped by 25% since 1982.

To increase the number of women entering and completing degrees in engineering, many more females must enroll in college preparatory mathematics and science classes in secondary schools. Only 18% of all high school seniors have taken physics and two-thirds of this group are males. The percentages are only slightly better for trigonometry. How can colleges of engineering help change these dismal percentages?

A number of lessons can be learned from minority engineering efforts which have labored persistently and effectively for the past 15 to 20 years to make a dent in the serious shortage of minorities in engineering and scientific fields. In the early 1970's the primary thrust of this effort was two-fold: a scholarship program for engineering undergraduates and motivational activities directed toward eleventh and twelfth graders. While these programs generated some measure of interest among students completing college preparatory programs, it became clear that a major endeavor was needed to significantly increase the pool of minority students enrolling in Algebra I and progressing through four years of subsequent mathematics and science courses in high school.

A Model Pre-College Program

With encouragement from the Alfred P. Sloan Foundation, six deans of engineering from five Southeastern states met in 1975 to explore ways to address the issue of "pool-building." From their discussions, SECME (the Southeastern Consortium for Minorities in Engineering) was born. By 1978, the successes of the program were so dramatic and the implications so far-reaching, the deans made the decision to secure funding for an ongoing program to broadly impact the entire region.

Today, SECME has 28 member colleges of engineering, 60 corporate members and more than 260 secondary schools in eight states participating. In 1989, 18,029 students participated in the program in grades six through twelve, 59% of whom were female.

Since 1980, some 27,000 SECME seniors have graduated from high school; 85% have continued their education. Their SAT and ACT scores have been significantly higher than the national average for minority students, the SAT by more than 200 points. Over 40% of those continuing their education have chosen engineering, computer science, mathematics or the sciences as majors. SECME has contributed significantly to the increase of 280 per cent in minority engineering enrollment in its member universities. One-third of the Black engineering baccalaureate graduates in the country now come from SECME universities.

What are the guiding principles that made SECME so successful? First of all is the partnership between colleges, businesses, industry, parents and school systems. To successfully prepare underrepresented students for majors in science and engineering, all of these parties must collaborate to provide the continuity a successful program demands. Businesses, universities, and parents are much more likely to become involved when there is a formal mechanism for participation.

The element of SECME's partnership that has been unique through the years is the active participation of schools. By working through the school system, securing the endorsement of the superintendent, the solid backing of the principal, and the active participation of the teachers, substantial changes can be made in the way students are identified, placed and encouraged to succeed in mathematics and science courses. Schools have the flexibility to develop and implement their own plans following SECME guidelines.

The classroom teacher holds the key to academic preparation and to motivating students by expecting academic success in school. Offering staff development to classroom teachers, assisting them to work as a team and in an interdisciplinary manner is critical to the development of a successful SECME school program. Unlike some other programs that focus on the students, SECME's fundamental objective is to train the teachers who teach the students and who remain after the students graduate. Thus, by directly influencing the delivery system, not just the products of that system, a program doesn't have to start over every year.

The subject areas critical to preparing young people for engineering include not only mathematics and science, but language arts and communications skills. Good communication skills are crucial if students are going to succeed in their life endeavors. Interdisciplinary instruction is strongly encouraged to facilitate learning.

Curriculum enrichment and hands-on activities are also fundamental to an effective instructional program. When you improve the curriculum in the classroom, you're benefitting all students -- not just minority students. As teachers provide experiences to increase interest in science and engineering careers, they become the student's most effective guidance counselors.

Another important guiding principle of SECME is early and active intervention. Minority students must be identified for SECME prior to enrollment in first-year algebra, and preferably as they enter the middle grades.

University members provide engineering faculty and industry members designate role model scientists and engineers to offer assistance in the classroom and to serve as mentors to both teachers and students.

A final and very important principal: support and participation of the parent both at home and at school. It is not enough for the teacher to communicate positive attitudes and expectations. Parents have greater influence than any other adults on young students!

"Why Aren't Women Entering Engineering?"

According to a report of the American Institute of Physics entitles Who Takes Science?: "All students have the right to a quality education. Yet women are clearly not receiving the encouragement, guidance or educational background needed to develop their abilities. Many capable females are being dissuaded from taking upper level mathematics and physics in high school. They are simultaneously being precluded from pursuing those fields as college majors and, thus they are unlikely to be able to compete in those sectors of the economy. In short, women have not been provided with the tools necessary to participate fully in an increasingly technological labor market and contribute to the economic future of this country."

Research suggests that a number of factors negatively affect the progress of women in mathematics and science. During elementary school, girls' attitudes toward mathematics are positive and they perform at least as well as boys in all subjects. But these positive attitudes begin to decline by late elementary school and the decline escalates as they progress through high school. Differences in mathematics achievement between males and females occurs by the eighth or ninth grade. Low achievement in mathematics is also associated with high test anxiety which is much more common among girls than boys.

Girls are not encouraged to find out how their toys work by taking them apart, thus losing a valuable opportunity to develop mechanical inquisitiveness and skills. By third grade, girls have been conditioned to accept toys as they are and not to manipulate or change them. By fifth grade they are reluctant to work with science toys. They tend to attribute their failures to lack of ability and their successes to luck, while boys attribute failure to situational and external factors. Once a student falls below the standard level of performance for a grade level, it is unlikely that she will ever catch up.

At age nine, the science proficiency for girls and boys is about the same except in physical science. By age 13, girls state that science fails to instill feelings of confidence, success or curiosity; instead it makes them feel stupid. By age 17 the performance difference between males and females is large.

Achievement in both mathematics and science is related to student confidence in ability to "do" mathematics and science. Girls self-confidence declines upon entering adolescence and is impacted by the view that mathematics and science are male activities. This perception creates low mathematics/science-concept in girls and contributes to low performance.

Student attitudes become more like those of their peer group as they approach the ninth grade. At this time girls experience a strong conflict between liking science and desiring popularity, especially with boys. Girls do not pursue advanced courses in either mathematics or science because taking such courses might hamper their social relationships with boys or make them appear "masculine." As girls proceed through adolescence, they see these subjects as declining in usefulness for themselves and increasing in usefulness for boys. They perceive little usefulness for future educational and career goals.

The quality of advice given to girls and boys by the adults with whom they interact is quite different. And, there are comparatively few female role models in these fields. Teachers treat boys and girls differently in mathematics classes. Boys receive more teacher praise and criticism concerning mathematical performance and are expected to perform better and excel in competitive games and contests. Girls are twice as likely as boys to be discouraged by their teachers from pursuing college majors and careers in mathematics, science and engineering.

Guidance counselors advise females not to take upper level mathematics. Sixty per cent of counselors believe girls are not interested in mathematics, do not need mathematics for their careers, and are not as competent in mathematics as boys. Forty-two per cent of girls who were interested in careers in mathematics or science said that they had been discouraged by their counselors rather than encouraged to take advanced courses.

Parents provide more support and encouragement to their sons than to their daughters. They believe boys do better in mathematics and mathematics is harder for adolescent girls than boys. Lack of parental expectation and encouragement discourages girls from excelling. While parents encourage academic performance in general, they tend to discourage daughters from entering quantitative fields of study in college. Parents view careers in science and mathematics as a male domain.

"How Can We Change These Dynamics?"

Research also indicates there are positive factors that enhance mathematics and science experiences of girls and women. A positive attitude toward mathematics has been identified as one of the most important factors affecting women's participation in mathematics. Achievement in mathematics is related to the student's confidence in their ability to "do" mathematics. The more favorably they view mathematics and their own competence to do mathematics, the more likely they are to persist.

Students' confidence in their mathematical ability is strongly related to their perception of teacher encouragement. The influence of teachers may be more important for girls, who receive less encouragement from other sectors of society to participate in mathematics. Teacher support can counteract the negative influences of parents, guidance counselors, and peers in encouraging girls to enroll and succeed in advanced mathematics courses. Girls have more positive attitudes toward mathematics in classrooms characterized by low levels of competition, high levels of cooperative learning and high levels of teacher communication regarding the intrinsic value of mathematics and the link between mathematics and interesting occupations.

Perceptions of parental expectations and especially maternal attitudes toward mathematics are important to girls. Girls who believe their mothers like mathematics express more positive attitudes. Having science hobbies during childhood also exerts a strong positive influence on girls. Girls report more experiences with plants and animals than boys, but substantially fewer experiences with magnets and electricity.

The middle school years are a crucial time to intervene and help develop and maintain positive attitudes toward both mathematics and science. Middle school should include an abundance of hands-on activities, especially related to concepts in physical science. Females express similar or greater desire than men to participate in science. The challenge is to convert this interest in doing science into increased participation in science courses and activities.

The use of role models is a potentially powerful technique to encourage and influence young women to choose science-related careers. Both girls' and boys' attitudes toward women scientists improved after being exposed to role models. Role models have an important impact in early adolescence especially when they participate in instructional programs.

"But an Engineering School's Mission Is ..."

Many engineering colleges have sponsored programs which have been successful in recruiting high school women into engineering. Those whom we recruit must be well along the way to completing their college preparatory sequence in math and science. Until those numbers increase, we will not see any major changes in the numbers or percentages of women enrolled in engineering.

It is imperative that we look at the "big picture" and make plans for the long term. We must focus on the early grades, helping to change the attitudes of teachers and counselors as well as the ways in which they teach and counsel. We can also assist with hands-on experiences and by identifying women engineers and scientists who can serve as role models and mentors to both students and teachers. We can encourage school personnel to look at the enrollment patterns of their female students in mathematics and science. And finally, by organizing and participating in local partnerships, we can promote systemic changes that will improve the academic preparation of all of our students.

Remember, our engineering graduates in the year 2000 have just completed the second grade!