

WOMEN IN ENGINEERING EDUCATION: PROGRESS AND PROJECTIONS

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Abstract

During the later half of the 20th Century, programs for women in engineering (WIE) were initiated in order to create greater educational equity for women. When professional engineering groups were first organized, only a few pioneer women were taking classes at or graduating from United States and Canadian engineering institutions. The number of women engineers remained low throughout the first half of this century, except for some gains during World Wars I and II. Progress, however small, was made in the early 1970's, when additional women in engineering program (WIEP) activities were launched, WIE enrollments rose, and WIE B.S. degrees reached one percent for the first time. Twenty years later, scope of WIEP activities has expanded, percent of WIE enrollments has more than doubled, and WIE B.S. degrees have escalated to 16 percent. Projecting to the year 2000, we can see that there will be increased participation of women in engineering education. Connecting, guiding, and supporting women engineers in academic institutions will be a challenge for engineering educators in the next century.

Introduction

Since 1883, women have been encouraged to participate in engineering education, however, their involvement in this field was not significant until 1972. That year, less than half of the engineering institutions enrolled women students and only a small proportion of these schools had formal programs with activities to recruit and retain women engineers. Females constituted only three percent of students who were enrolled for the first year in engineering and women managed to earn only one percent of all B.S. engineering degrees. Yet, as total number of engineering students grew during the next two decades, additional women graduated from engineering schools and became involved in the engineering profession.

Recent democratic trends in higher education indicate that number of male college students in the United States will decrease in the 1990's. [18] These students form a pool from which the majority of engineers are recruited. During this same time period, percentage of undergraduate female students will grow and these women will become the ones in demand when a projected shortage of engineers occurs. [14,16] Engineering is at a high level in the hierarchy of professional careers and women are paid well for their services when compared with salaries for other professional occupations. [14] This combination of demand and reward should make engineering an even more attractive field for females in future years. Therefore, there is concern about enlisting and supporting additional women in their pursuit of an engineering education. This leads us to an examination of changes in and relationships between WIE programs, enrollments, and degrees.

Progress in the 20th Century

Women in Engineering Programs

A steady growth in number of WIEP and scope of activities has occurred from 1975 to 1992. [26] According to data available from four national surveys of WIEP [1,22], number of institutions surveyed increased from 108 to 186 and scope of activities expanded from 395 to 859. In 1993, there were 331 out of 336 U.S. engineering institutions that enrolled women students in their curriculums. Formal WIEP existed at thirty one of these engineering institutions and considerable gains have been made in percentage of pre-college recruitment and college retention activities offered by WIEP. [1,22]

Percent of engineering institutions offering elementary school activities has increased from five to eighteen percent and those with junior high activities have expanded from 16% to 42% throughout the past two decades. [24] Approximately the same percentage of engineering schools (around 34%) throughout this span of time have held conferences for senior high school women. Institutions now realize that they need to expose young women to engineering as a viable career choice and to support them throughout their educational endeavors. [8,24] Wadsworth & LeBold [25] found that WIEP that focused on engineering as the topic and involved college students and faculty during retention events had high percentages of women enrolled as undergraduate engineering students.

Scholarships for female engineering students were awarded by some 90% of engineering institutions in 1992 as compared with 44% in 1975. Fellowships for graduate female engineering students were provided by 73% of engineering schools in 1992, but, only 20% in 1975. Presently, 88% of institutions have chapters of the Society of Women Engineers (SWE) on their campuses, up from 74% in 1975. [24] Research results indicate that high percentages of women engineers graduating with B.S. Degrees and enrolling as graduate students were respectively located at institutions where SWE supplied student volunteers for WIEP events and where SWE existed on the campus. [25]

Women in Engineering Enrollments

Parallel increases in percent and number of women enrolled in engineering education have occurred from 1975-1993. [10,13] Percent of women engineers enrolled as first year students doubled from 9% in 1975 to 19% in 1993, and, number of women enrolled as beginning students in engineering increased from 6,730 in 1975 to 16,954 in 1993. Throughout the same time period, total undergraduate enrollments for women engineers more than doubled from 7% in 1975 to 18% in 1993. Also, number of undergraduate women engineering enrollments rose from 15,852 in 1975 to 60,963 in 1993. Percent of women enrolled in graduate engineering programs climbed from 4% in 1975 to 15% in 1993. Further, number of graduate women engineering enrollments expanded from 2,443 in 1975 to a record of 19,568 in 1993.

Wadsworth & LeBold [25] discovered that women who become involved in engineering education seem inclined to attend either a private or public school with a middle range or high percentage of women engineers enrolled as undergraduate students. Apparently, a critical mass or sufficiently large number of women need to be present at an engineering school in order for the socialization process to be enhanced. [12, 18] These researchers also found that schools with fundings from their own institution for WIEP were likely to be in the middle range based on percentage of women enrolled as graduate students in engineering. One explanation for this finding might be that administrators located at institutions with large enrollments of women engineering students have become more concerned about the number of women who are considering graduate education. Therefore, they are committing some of their financial resources to the goal of increasing graduate enrollments.

Women in Engineering Degrees

There has been a rise in percent and number of women receiving engineering degrees at the bachelor, master, and doctoral levels. [10,13] Percentage of WIE B.S. degrees changed from 1% to 16% during the years 1972-1993, and, number of degrees increased from approximately 500 in 1972 to 10,453 in 1993. Percentage of WIE degrees at the master's level escalated from 2% in 1972 to 16% in 1993. Number of WIE M.S. degrees expanded from near 300 in 1972 to 4,876 in 1993. Finally, percent of WIE Ph.D. degrees grew from 1% in 1972 to 10% in 1993, while, number of doctoral WIE degrees changed from 35 in 1972 to 600 in 1993.

As noted previously, a great deal of progress has been made from 1975-1992 in total number of WIEP activities. Results of statistical analyses [26] indicate that mean number of 1987 WIEP activities per engineering institution positively related to B.S. Engineering Degrees awarded to women at United States engineering institutions. Also, institutions with NSBE and SWE organizations existing on their campuses, supplying student volunteers for WIE events, and administering their own activities, had higher percentages of women engineers graduating from their schools. [25] Further, in a 1991 study, Wadsworth, LeBold and Daniels found that the larger the number of women awarded 1990 B.S. engineering degrees, the greater the percentage of women earning the same degrees at engineering institutions, until, a critical mass of approximately 50-70 women students is reached. [26]

Projections for the 21st Century

Full participation of women in the life of a society should be our joint concern. Since engineering has the lowest proportion of women students, when compared with other fields in higher education, we need to level the playing field for women in engineering. I wonder, do we presently shape engineering education in such a way that competent women are excluded from considering, entering, or remaining at our institutions? Can we reshape engineering education in the future in order to assure women students that we are committed to their consideration of, admittance to, and matriculation in the field? If so, what can we predict will occur in future years for women in engineering education? Let's begin by taking a look at several problems, addressing current needs, and considering model activities that could change the future state of WIE programs, enrollments, and degrees.

Women in Engineering Programs

Starting with programs for women engineering students, a major problem is the small number of formal WIEP across the United States. [25] Thus, we need to assist engineering institutions in establishing and/or expanding their WIEP through regional initiatives. [9] A model activity that relates to this problem is the Women in Engineering Program Advocates Network (WEPAN) Regional Training Seminars under the direction of Susan Metz, Stevens Institute of Technology. [9] At seminar sessions, WEPAN officers and WIEP administrators provide technical assistance as a means of helping attendees define program goals, develop financial support, create new activities, and assess their efforts.

Continuing with pre-college or recruitment activities, one concern is the lack of competence in math and science that is necessary for young women to have when entering the engineering field. [21] One need that is linked with this concern is to encourage female middle and high school students to take math and science courses which provide hands-on experiences that help develop mechanical "tinkering" skills. [3,14] An activity that is connected to this recruitment problem is the Summerscience Program developed by Cinda Sue Davis at the University of Michigan. [18] The ninth grade students in this program become involved in computer and lab projects designed to enhance feelings of competence.

Concluding with college or retention events, there is limited acceptance and understanding of diversity on the campuses of engineering institutions. [11] Therefore, we need to develop a set of multifaceted activities that speak to the diverse needs of women engineering students. [8] One model activity that is linked with this retention problem is the Faculty Awareness Training offered by Michele Fish at Cornell University. [11] The Cornell Interactive Theater Ensemble presents workshops that heighten faculty awareness of cultural biases which can undermine the success of women engineering students.

Women in Engineering Enrollments

Contemplating first year enrollments for women engineering students, one problem is the general decline in a college age population which leads to greater competition among engineering institutions for existing students. [5] Administrators at universities need to create unique approaches to enrolling women into engineering. [19,23] One successful approach has been the Personal Connection Program launched by Emily Wadsworth at Purdue University. [23] This program enlists the help of current and former students as well as parents in recruiting more high school seniors into engineering. Through phone calls, business visits, meals, and letters, information about engineering is shared and questions about courses, careers, housing, etc. are answered.

Looking at undergraduate enrollments for WIE, a concern has been assessing factors which affect women when they make their decisions about college majors. [12] Researchers need to survey female students, who enroll in engineering, about factors that influenced them in making college decisions. [12] Carol Shaw at the University of Dayton has conducted long term studies of factors affecting WIE enrollments. [17] She discovered that WIEP activities helped women students to select their college majors and formulate long-range goals.

Considering WIE graduate enrollments, institutions are struggling with the challenge of generating enthusiasm among women for contemplating how engineering is solid preparation for other occupations. [23,27] Directors of WIEP need to develop new recruitment materials that illustrate the many ways engineering backgrounds form solid foundations for future professional careers in law or medicine. [3] Videotapes for prospective women graduate students, created by Jane Daniels at Purdue University, are related to this enrollment problem and need. [23] The videos are visually intriguing and they showcase campus, faculty, and engineering facilities.

Women in Engineering Degrees

A major problem at institutions is the poor retention rate for women engineering students. [20,23] Apparently, the chilly climate that exists at engineering schools, meaning isolation, criticism, and subtle differential treatment, discourages women from remaining in the field. [14,18] Women students generally have an affiliative or affective orientation to higher education, in other words, a high need for personal support, relevant information, and effective strategies to utilize throughout their college years. [6,15] During the first year in engineering, often a period of transition for students, women benefit from being connected with other female students in program activities. In order to address this problem and need, a study center, to facilitate collaborative learning, has been established at the University of Washington under the direction of Suzanne Brainard. Through intervention activities offered at the center, first year women engineering students receive encouragement, knowledge, and guidance from upperclass female students. [4] Such efforts can lead to larger proportions of women graduating with B.S. degrees in engineering.

Another reason why women switch out of engineering is because they encounter a limited number of female role models. [6] We need to expand the number of women who are graduate students, faculty members, and administrative staff, for, academia helps shape the culture of engineering. [14] One means of accomplishing this is to incorporate students in research projects. [2,3,18] Myrna Whigham has directed the Research Internship Program at Iowa State University that gives women the opportunity to attend seminars, conduct research work, and prepare reports, all of which are critical in the pursuit of a master's degree in engineering. [29]

Since the number of minority college students with engineering degrees continues to climb, it will become increasingly important to have close cooperation between minority and women's engineering programs. [7,13,27,28] The Minority Affairs and Women's Programs, headed by Carolyn Williams at Vanderbilt University, is an example of how forces can be joined to create united services like course tutoring and evenings with industries. [30] In this way, the strengths of women representing multi-cultures are utilized to help students as they develop through their doctoral studies.



Projections

Projecting into the future, we can see that variations will occur in relation to WIE programs, enrollments and degrees. [26] Number of engineering institutions with formal WIEP will continue to increase and total number of activities offered through these programs will amount to more than 1000 in coming years. Women engineering students will constitute 25% of first year enrollments by the year 2000 (up from 19%). That same year, percent of women earning B.S. engineering degrees will have increased from 16% to 27% (an 11 point gain), those with M.S. engineering degrees will have risen from 16% to 23% and those with Ph.D. engineering degrees will reach 13% (up from 10%).

Expanding the percentage of women engineers in the 21st century will require a warm versus cold climate, also, a state of inclusion versus exclusion at the secondary school level and on through the college years. An old Chinese Proverb indicates that unless we change direction we are likely to end up where we are headed! Recruiting, retaining, and graduating more women engineers could lead to future payoffs. As women become more involved in academic, business, industrial, governmental, and political worlds, their "yin perspective" will stretch the boundaries of the "yang paradigm." [15] The profession would then reflect society more accurately and women could bring a different dimension to the workplace. Well supported women engineers could in turn train other engineers to lead us into the next century of engineering education.

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