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Women Engineers: A Study of Educational Preparation and Professional Success

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ABSTRACT

In an effort to better understand the educational experiences and professional issues facing women in these fields, a survey of women alumnae was conducted. Respondents seemed fairly pleased with the education they received and were heavily influenced by personal aspects of the campus. Relationships with faculty members were described as their most beneficial and detrimental experiences. They particularly liked opportunities to apply their technical knowledge but did not believe there were enough opportunities for application. The need for more female role models and importance of involvement in student organizations were cited by many of the respondents. Self-confidence and good communication skills were rated as the most important qualities for professional success and advancement. Alumnae have pursued training experiences since graduation, but would like to see more opportunities to enhance communication and personal management skills and apply theoretical knowledge built into the undergraduate experience.

The findings are discussed in relationship to previous research studies and recommendations are made to improve the technically oriented college environment.

I. INTRODUCTION

Several recent articles have focused on increasing the number of women in the engineering profession. Suggestions have been made to recruit more women into the pipeline and to retain them in university programs. This research focuses on women alumnae, who have made it through the pipeline and their views of their college experiences and professional issues. It is the aim of this project to examine how college education prepared alumnae for the professional world.

A sample of 500 alumnae from a mid-western university were surveyed to examine their educational experiences and current professional status. These women had earned a B.S. degree in one of 12 engineering or computer science disciplines from 1979 through 1987. Half of the sample completed and returned the

survey and the information that follows is based on those alumnae responses.

II. COLLEGE EXPERIENCES

The alumnae were pleased with their educational experiences and indicated that they had received an excellent technical education that provided them good access to employment opportunities. Areas in which respondents felt they were strongest upon graduation were: 1) theoretical technical knowledge; 2) ability to work as a team member; 3) writing skills; and 4) managing multiple priorities. Respondents felt they were weakest in supervisory skills, recognizing the informal organizational structure, and knowing how to deal with prejudices. There were no strong differences between years of graduation. Table 1 illustrates respondents' perceived skill level in a variety of areas upon graduation from college.

Although the university had exceeded their expectations in many areas, respondents expressed dissatisfaction with their liberal arts education, academic advising, and critical thinking enhancement. Over 40% of the respondents felt that academic advising was worse than they expected. On the positive side, over 60% of the respondents reported that the access to employment opportunities was better than they expected. Academic excellence, the learning environment, and the technical education also exceeded their expectations. Table 2 illustrates the extent to which the university met alumnae expectations in twelve areas.

Relationships or interactions with faculty were frequently cited as beneficial college experiences. Alumnae commented that certain individuals "went to bat for me" or "made me feel as if I could do anything I set my mind to." The one respondent who received her Ph.D. spoke of a professor who "was interested in the students and encouraged them to pursue goals, like obtaining a Ph.D. at M.I.T." This finding supports previous research that women need encouragement and support to pursue their professional goals⁽¹⁾.

Several other aspects of the personal/social environment were described by the respondents. The small school environment allowed them to develop comradeship with people who had common goals and desires. They grew from participation in social activities and believed that leadership positions in student organizations helped them develop skills which later enhanced their career. Involvement in student organizations was high for some of the respondents. Over 70% of the respondents belonged to student professional organizations with 20% of them holding an office in these organizations, and over 50% of them belonged to interest clubs and/or honor organizations with 20% of them holding leadership positions. The percentage of women holding leadership positions in student organizations exceeded the cam-

Table 1. Perceived Skill Level Upon Graduation
Mean Score for all respondents
Scale - 1 (Much better than expected) to 5 (Much worse)

Parameter	Overall Rating
Theoretical Technical Knowledge	2.22
Ability to Work as Team Member	2.32
Writing Skills	2.42
Managing Multiple Priorities	2.54
Application of Technical Knowledge	2.58
Interpersonal Communication Skills	2.60
Understanding Ethical Standards	2.72
Time Management	2.77
Oral Presentaiton Skills	3.00
Recognizing Formal Organizational Structure	3.13
Business & Social Etiquette	3.16
How to Deal with Prejudices	3.26
Recognizing Informal Organizational Structure	3.26
Supervisory Skills	3.35

Table 1. Perceived Skill Level Upon Graduation.

Table 2. Extent to Which the University Met Expectations
Mean Score for all respondents
Scale - 1 (Much better than expected) to 5 (Much worse)

Parameter	Overall Rating
Access to Employment Opportunities	2.27
Academic Excellence	2.43
Learning Environment	2.47
Technical Education	2.49
Extracurricular Activites	2.57
Social Life	2.65
Personal Acceptance & Growth	2.76
Leadership Experience	2.76
Career Preparation	2.83
Critical Thinking Enhancement	2.91
Academic Advising	3.27
Liberal Arts Education	3.35

Table 2. Extent to Which the University Met Expectations.

pus percentage of women students in engineering. At the present time women students are even better represented in leadership positions in student organizations. Women represent 16.8% of the student engineering population, but hold 30.0% of the presidential positions in departmental organizations and 38.5% of the presidential positions in honor organizations. This supports Baum's⁽²⁾ research that women engineering students are "achievement-oriented females" with good leadership potential and are highly attuned to the personal/social environment.

Complaints about college experiences centered around personal/social needs not satisfied by the environment. Academic advising was raised as an area of dissatisfaction in several of the open-ended remarks as well as in ratings of expectations. Several alumnae reported their advisors being unsupportive and negative and some believed they made the wrong choice of academic majors because of lack of guidance in selecting a course of study.

Some respondents (over 25%) reported being discouraged by the negative attitudes of some faculty members, and a smaller percentage (about 18%) experienced sexual harassment as an engineering student. A majority of these respondents reporting discouragement and/or sexual harassment graduated in the late 70's and early 80's.

Many respondents felt the need for more female role models in the college environment, with some respondents reporting the lack of female role models as being detrimental to their education. This finding is consistent with previous research citing the importance of role models for women to pursue non-traditional careers⁽¹⁾. It has also been shown that personal aspects of the college environment are important for women students and that they need interaction with and encouragement from faculty and staff⁽³⁾. With inadequate female role models in engineering and science on college campuses, it is particularly important for male faculty to provide encouragement and support for female students who pursue education in technical fields.

Opportunities to apply technical knowledge was frequently mentioned by respondents. Those who had such opportunities through jobs, the cooperative education program, and/or the undergraduate research program cited this as one of their most beneficial college experiences.

The lack of applications of theoretical knowledge was a frequent complaint by respondents who did not have these opportunities. One respondent commented that "women need more hands-on experiences because they missed the opportunity to learn mechanics from their fathers." This supports previous research that lack of hands-on experiences is a barrier for females pursuing a technical education. Women students need more opportunities to apply their technical knowledge while pursuing an undergraduate education.

A variety of suggestions were made for improving the environment for women students. Their primary requests were to increase the number of female faculty and staff members so that more role models were available for female students, and to bring women engineers to campus to provide professional seminars. Respondents also suggested more training opportunities to further develop personal skills in assertiveness, self-confidence enhancement, time management, and stress management. Alumnae would like to see more encouragement from professors and better attitudes and treatment from male students. Although some requests were made for more women students, another

frequent suggestion was to encourage women students to get involved in student organizations, and support groups.

III. PROFESSIONAL EXPERIENCES

The majority of the respondents had some type of work experience while attending college, and are currently employed as engineers in an office environment for a major organization. They view themselves as moderately successful in their careers, have received at least one promotion, have had professional training experiences since graduation, and their average annual salary has increased with the number of years since graduation. Most are married to engineers or computer science professionals and have children.

All of the respondents had obtained training and/or further education since graduation. Over 25% had obtained additional degrees. In combining all groups, alumnae have received post-graduate training to update and expand technical skills (46%); develop supervisory and leadership skills (43%); enhance oral communication skills (41%); learn time management (39%); enhance written communication skills (33%); attend assertiveness training (31%); learn stress management (30%); better understand professional ethics (27%); and learn motivational techniques (26%).

Post-graduate training in supervision/leadership, assertiveness, and oral presentation skills showed significant trending by year of graduation. Many of the earlier graduates had training in oral presentation skills (67.4%), supervision and leadership skills (65.2%), technical skills (56.5%), motivational techniques (41.3%), time management (47.8%), and stress management (47.8%). This training is consistent with their progression into management positions and their personal/professional issues and concerns.

The issues that posed the least problem for respondents were mostly communication based: communicating with colleagues and subordinates, writing reports, working as a team member, and confronting ethical issues. This supports previous research which found that women tend to have good human relations and verbal skills⁽³⁻⁴⁾.

The primary problems that respondents have experienced centered around personal management. Managing stress, balancing personal and professional demands, and managing time were the three biggest problems. Balancing demands was the number one problem for the 1979 and 1981 graduates, who also had the most children. This is indicative of the pressures associated with combining career and family.

Promotion opportunities, gaining credibility, sexual harassment/ discrimination, and understanding informal organizations were viewed as problems for the earlier graduates.

These issues have been called "psychological roadblocks to success" for women in technical fields⁽⁵⁾. Since we do not know the temporal sequence of these problems for the earlier graduates, one cannot be certain whether these issues surface a few years after graduation when they begin moving up the career ladder or if the work environment is becoming more accepting of professional women in technical positions. The earlier graduates had more management related concerns—managing conflicts, communicating with subordinates, making decisions, setting goals, and

giving oral presentations. This finding is consistent with the higher percentage in management positions and their training experiences in leadership skills, assertiveness, communication skills and stress management. The increase in these training experiences with time is an indication of the importance of these skills for professional advancement.

Self-confidence was ranked as the most important element for professional success and advancement, followed by communication skills. A variety of personal skills were also rated as more important for professional success and advancement than strong technical abilities. Table 3 illustrates respondents' ratings of skills important for success and advancement.

IV. CONCLUSION AND RECOMMENDATIONS

Based on the responses of the alumnae surveyed and national trends indicating a rapidly growing need for highly trained technical professionals, some improvements in the technical college environment are warranted. Efforts need to focus on making technologically oriented careers and college environments more attractive to women. Although women make up over 50% of the college age population in the United States, only 14% of the students in engineering curriculum are women⁽⁶⁾. In the professional world only 6% of practicing engineers and 2% of engineering faculty members are women⁽⁷⁾. Of the women who complete a degree program in a technical field only half choose to work in their discipline.

Crow and Hubing⁽⁸⁾ examined several university programs designed to increase the recruitment and retention of women engineering students. Successful programs/activities include pre-college programs, Women in Engineering Program scholarships, active chapters of Society of Women Engineers, seminars, newsletters, social activities, service projects, industrial visits, and job search assistance. There was a direct relationship between special university programs and the percentage of women engineering students on campus, but even the universities with long-term, comprehensive recruitment and retention efforts have only achieved enrollment percentages of 22%. The results support the need to go beyond special programming for women students and to look at revising the general atmosphere on many technologically oriented college campuses (see Table 4).

Efforts can be made to develop positive student-oriented college environments. Faculty members may need to be educated about the changing ratio of the student body, needs of female and minority students, and retention issues. Colleges must be more consumer-oriented if they are to grow and prosper. This translates into treating both female and male students better and avoiding subtle and overt behaviors in the classroom and on campus that promote a chilly climate for women⁽⁹⁾.

Research has demonstrated that student retention can be increased through improved academic advising⁽¹⁰⁾. Since most faculty members have had no training in academic advising and have not received awards (tenure, raises, etc.) for good advising, the change will have to begin at the top. Faculty will need to be trained in proper academic advising and the quality of advising

**Table 3. Importance of Skills for Success & Advancement
Mean Score for all respondents
Scale - 1 (Very Important) to 5 (Not Important)**

Parameter	Overall Rating
Having Confidence in Self	1.24
Oral Communication Skills	1.29
Written Communication Skills	1.55
Ability to Listen Objectively	1.55
Ability to Work as Team Member	1.62
Managing Time	1.72
Critical Thinking Abilities	1.75
Being Assertive	1.82
Leadership/Supervisory Skills	1.84
Managing Stress	1.85
Conflict Negotiation Skills	1.97
Strong Technical Abilities	2.00
Balancing Professional & Personal Demands	2.08

Table 3. Importance of Skills for Success and Advancement.

Table 4. Recommendations to Enhance the College Environment for Women Students

- 1. Develop a friendly student-oriented campus environment**
- 2. Encourage more positive faculty interactions with students**
- 3. Improve academic advising through advisor training, monitoring, and rewards**
- 4. Expand classroom experiences to include more team projects and presentations to enhance communication skills**
- 5. Offer more opportunities to apply theoretical technical knowledge**
- 6. Encourage and support student involvement in organizations**
- 7. Provide training in personal management skills**
- 8. Increase the number of visible female role models on campus**

Table 4. Recommendations to Enhance the College Environment for Women Students

will have to be monitored and appropriate rewards given for good performance in this area. All students could benefit from this change.

In the classroom, the focus must still be on educating students in important technical areas. However, classroom experiences can include more team projects and presentations to enhance communication skills. The focus could be placed on helping all qualified students learn and excel rather than placing it on a detached competitive attitude to weed out students. Students, especially women students, will thrive in an environment where they are involved in the learning experiences and feel like the faculty are there to help them learn.

Opportunities to apply theoretical technical knowledge are needed. Women students often lack the hands-on experience many of their male peers have had.

These experiences can include cooperative training programs, part-time employment on campus, summer internships, undergraduate research activities, and class projects. Application experiences can reinforce theoretical learning and hence increase enthusiasm for learning.

A breadth of activities need to be available to accommodate the desire alumnae expressed for diverse involvements. Liberal arts courses and participation in student organizations can be encouraged by faculty advisors. Campus support of student organizations is a way of promoting student involvement. Some campuses have co-curricular transcripts to encourage and show involvement in student organizations. Senior seminars can include training in assertiveness, stress management, time management, and communication skills. They can be offered jointly by Student Affairs Staff and Engineering/Science Faculty. Faculty can also encourage students to attend non-credit workshops in these areas, and women in technical professions can be brought to campus to offer these and other workshops. These successful professionals would serve as positive female role models.

Increasing the number of female role models in key faculty and staff positions will take time, and it will need to continue being a campus priority. Colleges can become involved in pre-college

programming efforts to increase the potential number of women engineering students in the pipeline. It must be kept in mind that women faculty and professional staff are looking to work in the same kind of environment that female college students are seeking—a friendly campus that provides high quality technical education as well as diverse and equal opportunities for interaction and involvement. They are seeking an environment that encourages the personal and professional growth of students, faculty, and staff. By moving in that direction, college campuses can attract and retain more students, faculty, and staff of both sexes.

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