# Are You Serious?
# Women in Engineering

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## Abstract

Several studies of engineering students have shown that academic performance determined whether men persisted in the program while personal factors were more likely to influence women's decision. Few studies have focused on the social variables that may influence a student's decision to persist in engineering. In the study reported in this paper, the investigation replicated earlier findings and also included the influence of social factors. Academic performance and personal factors were found to be important indicators of persistence. Social factors, such as friendship networks and the engineering environment (learning and working), also appeared important. The most serious problem women faced in engineering, whether they persisted or not, was not being taken seriously. Men indicated further that women did not have the ability or commitment for an engineering career.

Until interest patterns and career expectations can be influenced so that more young women are willing to pursue an engineering degree, attention needs to focus on retaining more women once they have begun their engineering program. In her analysis of retention rates for men and women in engineering, Ott (1978) estimated that the percentage of women who left engineering during their sophomore year was higher than men, 32% and 27% respectively. Shell and his colleagues (1985) found a bigger gap by the end of the junior year where 45% of the women had left compared to 26% of the men. Women who have withdrawn from engineering have generally remained at the university in another major while men have left the university entirely (Ott, 1978). Over the short-run, an increase in the representation of women among engineering graduates may have to come through the retention of those women who have made a commitment to a science education.

## RETENTION OF WOMEN IN ENGINEERING

While only a few studies have examined the retention of students in engineering, these analyses have drawn upon two national and a comprehensive institutional data bases for their conclusions. Lebold (1987) has summarized these studies as showing that men generally leave as a result of academic problems while personal factors were more likely to cause women to leave engineering programs.

Ott (1978) has found that high school academic achievement

In a critique of the retention literature, Chipman (1987) was not surprised to find that academic performance played a major role in persistence. She was, however, disappointed that more attention had not been given to social variables that may be working against women. In particular, faculty encouragement, mentors, financial resources, and friendship networks may play important roles in how women perceive the field and their decision to remain in the field.

Another factor that Hornig (1987) discussed as affecting a woman's persistence in engineering was self-confidence. Men and women apparently react differently to available rewards. Even though women's academic performance was equal to or exceeded the performance of men in the sciences, men's self-confidence was higher (CEEWISE, 1979; Feldman, 1974; Maccoby and Jacklin, 1974). Hornig has surmised that one reason for women's low self-confidence is the nature and quality of contacts with faculty. The sex of the faculty member has been related to this loss in confidence (Tidball, 1973 and 1976). Other relationships which have not been related to retention, but may be important, concern perceptions of the work place, specifically limited career opportunities, possible workplace discrimination, and less recognition for achievements (Hornig, 1987).

pre-engineering in the year of the study, but were not enrolled at the university the previous academic year); Changers (switched majors during the academic year); and Transfers (entered the engineering program beyond the freshman year, either from another college within the university or from a two-year institution). Within these groups, women and minority students were identified. All minority students were included in the study. A weighted sample of White students, stratified by gender, was drawn. Slightly more men were sent surveys to adjust for the expected lower response rate among men. The only group not included in the sample was senior engineering students, except those from a small pretest, because they were participating in another study that overlapped this project. A total of 2,400 surveys were distributed including a small group solicited for a pretest. A telephone follow-up was conducted approximately two to three weeks after the surveys were mailed.

Survey

A questionnaire was designed to capture different facets of a student's experience in engineering. In the first section, participants were asked questions concerning (1) their perceived competence in certain skill areas (compared to their high school peers), (2) involvement in extracurricular science programs and clubs while in high school, (3) individuals and factors that influenced their decision to pursue engineering prior to entering

## Results

The respondents to the survey were representative of the engineering school population. Approximately 48% of the respondents were women. This figure was higher than the overall enrollment of women in the engineering (approximately 30%). However, women were oversampled because the primary focus of the study was on women.

Freshmen represented 23% of the sample with sophomores, juniors, and seniors representing 31%, 30%, and 16%, respectively. The distribution of respondents across groups meet a priori expectations, based upon university enrollment patterns (Simpson 1986): 14% changed major; 21% were first time students; 33% left engineering for another major, 26% persisted in engineering for more than one year; and 7% transferred into the engineering program from other majors at the university or from another institution.

The composition of the respondents who majored in engineering reflected the enrollment distribution within that college, except for a low response from chemical engineers. For students who left engineering, their movement was consistent with earlier observations that found Leavers entering agriculture (packaging engineers), business, and the natural sciences (Simpson, 1986). A few students moved to the social sciences and humanities programs. The current academic major distribution of participants is provided in Table 1.

enjoyment of problems-solving, were considered important reasons for choosing engineering, especially by women. Among the women'sgroups, Leavers rated internal factors significantly lower. These ratings suggest that women who leave engineering may not have had the internal motivation necessary to persevere in the field.

Other Factors. High school experiences (classes, academic performance in selected classes, and vocational tests administered in high school), role models (parents, friends, and other engineers) and activities (hobbies, science fair participation, and familiarity with computers) were rated less important in the choice of engineering. Women rated high school experiences and role models more important than men (all significant at $p \leq .05$). Men attributed their interest in engineering more to activities outside of school, particularly science-related hobbies, computer use, and science fair involvement (a school related activity), than women (significant at $p \leq .05$)

Among the women's groups, no statistical differences were found, except between First-Time Arrivers and Persisters, over the importance of outside activities. Freshmen revealed that they spent more time in science-related activities outside of school than those women who had finished high school several years earlier.

Academic Preparation. Expected differences were found in the academic preparation and the academic performance of men and women while in high school. Men took one to two more math and

expectations (doing well in courses and meeting personal and faculty expectations); free-time (time for leisure and social activities); goals (career and personal goals); and discrimination (sex and race) were not considered serious problems by subjects in our survey (Table 3). Problems that did arise in these areas concerned goal uncertainty, lack of free-time, and incompatible expectations. The most serious problems were associated with coursework performance.

The engineering experiences of women and men were very similar. The only significant differences were for laboratory problems ($p \leq .10$) and discrimination ($p \leq .05$) with women rating both types of problems higher. However, fewer problems were reported in these areas compared to problems under expectations, free-time, and goals.

Some important differences were obtained among the groups of women. Leavers had more problems with their academic performance, and incompatibility of expectations and goals incompatibility than Persisters. While Persisters and First-Timer Arrivers also felt they did not have enough free-time, it was only the Leavers who adjusted their schedules to allow for more free-time and social life.

Time Allocated to Daily Activities. In a typical 24 hour week day, students spend the majority of time sleeping, studying, and in class. The remaining time is spent in a variety of activities, including work, fitness, and relaxation. Men and women differed somewhat in how they allocate their time. Women

Men's and Women's Expectations of the Engineering Program.

Various aspects of the engineering program were rated in terms of whether or not they met the individual's expectations. Eleven dimensions of the engineering program were evaluated (Table 5). The ratings were made on a scale of 1 (e.g., less, lighter or worse than expected, to 7 (e.g., more, heavier, or better than expected. A score of four (4) indicated a position equivalent to what the individual expected at the time of enrollment. Most of the ratings' means were close to the midpoint. The difficulty of the coursework surprised both men and women (women slightly more than men), as being harder than expected. The program was also longer than expected for some students. Less financial support, faculty interaction, and advising than expected were also reported. Women found their social life to be somewhat less than expected in comparison to men ($p \leq .05$). Women did enjoy more support from family than they expected, as compared to the men.

Groups of women had similar responses as to their expectations after entering the engineering program. Only three significant differences were observed. Persisters and First-Time Arrivers had a much more optimistic view of their career prospects than Leavers. Persisters and First-Time Arrivers also enjoyed more family support than originally expected as compared to Leavers. The one area where Persisters and First-Time Arrivers found less than they expected was financial aid. The breakdown of the ratings between groups reaffirms that among these groups of women, some may not have realistically foreseen what the engineering program was like.

Friendship Networks. Men had more friends than women (Table 7). However, the large standard deviations indicate that students tend to have a lot of friends or very few. Men were more likely to have more friends in engineering than women, but the difference was not large.

Among groups of women, Persisters had more friends than Leavers, and more of these friends were in engineering. This comparison may suggest that women who are successful in engineering find support from a wide circle of friends that includes other engineers. However, the similarity between Leavers and First-Time Arrivers suggest that Leavers may disengage from engineering before they can find a supportive friendship network. Or, not having a friendship network (for some other reason) caused them to leave. The evidence is not clear as to influence of friendship on persistence but, at this point, friendships can not be discounted.

## Career Expectations

Issues in the Engineering Field for Women. The problems women face in engineering are varied and may depend on individual experiences. A list of 20 problems unique to women in engineering was generated by discussion with a number of women engineers. All respondents were asked to rate the seriousness of these problems to women, as they perceived the situation.

Two observations stand out when reviewing the results (Table 8). First, men and women differed on eight issues. However,

significant ways (both at the $p \leq .10$): high school preparation and familiarity with lab equipment. More differences were found between First-Time Arrivers and the other two groups These differences likely stemmed from the limited exposure to the engineering program that the freshmen had at the time of the survey. Their perceptions of engineering may change as their involvement in the engineering program increases.

## CONCLUSIONS

In his observation of several cohorts of engineering students, Simpson (1986) found that approximately 37% of the students left the program by the end of the junior year. As this study suggests, the compelling reasons for leaving Engineering were academic performance and personal reasons. With restrictions for admittance to the upper division engineering program, grade point in selected classes becomes the measure for acceptance. The majority of Leavers have identified mathematics as the area that caused them the most problems. Changes in personal goals or career aspirations also influenced some students to switch from engineering.

Men were more likely to leave because their academic performance did not meet the College's requirements. From comments on the surveys, it was clear that many men were frustrated by their math courses. They were likely to blame the math instructors and their high school preparation. Several men

thus, often limiting women to female-dominated occupations. Women in this study finalized their career decisions later than women generally do. This difference may reflect the situation among women with technically-oriented work interests rather than all women pursuing a college degree.

The fact that role models were not more important was unexpected. Previous research on women in engineering shows that women received encouragement from others (Goggins and Lindbeck, 1986; Houser and Garvey, 1983; Noeth, Engen and Noeth, 1984; also see Sparrow and Newman, 1988). These results are consistent with Sparrow's and Newman's findings of little support for the importance of role models among women in science, except for several significant ethnic relationships. (Our report also found similar ethnic differences which have not been reported here).

The difference in time spent in paid work, nearly 3 hours per week, for men and women may be more revealing than the allocation of the time spent studying. The need to work has dramatically increased as the cost of higher education continues to soar. Monitoring the influence of work on academic performance and persistence may be helpful, especially as more hours may be allocated toward work.

Social support systems seem to play a role in the persistence of engineering students. Men and women who persist in engineering seem to have more friends and of those friends, more of them are also in engineering. At this point, we are examining the influence of social support systems in a causal

their male peers.

These results have certain implications for retaining women in engineering. Women need to be advised to take as many math and science classes as possible in high school. There is little that can be done if the interest of the individual changes, however. As Chipman (1987) and Hornig (1987) contend, women with improving quantitative skills need to be encouraged at an early age to develop an interest in science and engineering. Stronger interest, especially internal reasons, at the time of matriculation to college could lead to a higher completion rate.

Once at college, women need to be encouraged in their math courses. Social support systems by matching freshmen and sophomore women with upper division women who are making successful progress may also be helpful. Nevertheless, building social networks may only be a small step forward. For women, the main problems center on the acceptance in the field. They have little control over the attitudes of the male counterparts.

For men, the path for staying in engineering is simpler: improve their classroom performance. Men usually matriculate to college with the maximum number of math and science courses available. Plus, they have a strong interest in mechanical and technical activities. Men tend to encounter, rather early, problems in math. Some of the time spent in relaxing, socializing, and physical fitness could be redistributed to studying. It may be helpful for men to borrow some of the study habits from women to assist them in making better academic progress.

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Table 1. General Characteristics of the Sample Population

| Current Major | n | % |
|---|---|---|
| Agricultural/Resources | 40 | 6.6 |
| Business | 62 | 10.2 |
| Social Sciences | 19 | 3.1 |
| Natural Sciences | 46 | 7.6 |
| Other | 31 | 5.1 |
| Engineering | | |
| No Major | 51 | 8.4 |
| Chemical | 32 | 5.2 |
| Civic | 16 | 2.6 |
| Electrical | 92 | 15.2 |
| Mechanical | 82 | 13.5 |
| Computer Science | 59 | 9.7 |
| Engineering Arts | 44 | 7.3 |
| Other | 23 | 3.8 |

| Gender: | | |
|---|---|---|
| Female | 48% | |
| Male | 52% | |

| Current Standing | n | % |
|---|---|---|
| Freshman | 139 | 22.9 |
| Sophomore | 186 | 30.7 |
| Junior | 183 | 30.2 |
| Senior | 98 | 16.2 |

| Category | | |
|---|---|---|
| Changers | 86 | 14.2 |
| First Time Arrivers | 125 | 20.6 |
| Leavers | 198 | 32.7 |
| Persisters | 155 | 25.6 |
| Transfers | 41 | 6.8 |

Table 3. Problems Encountered by Students While in the Engineering Program

| | Gender | | Women | | | Overall |
|---|---|---|---|---|---|---|
| | Women | Men | Persisters | Leavers | First-Timers | |
| Personal | 2.31 | 2.37 | 2.30 | 2.36 | 2.24 | 2.34 |
| | (1.11) | (1.19) | (1.12) | (1.23) | (0.88) | (1.15) |
| Laboratory | 2.67 ** | 2.46 | 2.77 | 2.59 | 2.56 | 2.57 |
| | (1.33) | (1.28) | (1.30) | (1.46) | (1.22) | (1.31) |
| Expectations | 4.93 | 5.54 | 4.73 * | 5.17 | 5.02 | 4.98 |
| | (1.43) | (1.34) | (1.48) | (1.36) | (1.36) | (1.42) |
| Free Time | 4.12 | 3.94 | 4.35 * | 3.78 | 4.06 | 4.03 |
| | (1.57) | (1.56) | (1.52) | (1.63) | (1.55) | (1.55) |
| Goals | 3.77 | 3.78 | 3.42 * | 4.41 * | 3.69 | 3.78 |
| | (1.77) | (1.92) | (1.68) | (1.70) | (1.86) | (1.85) |
| Discrimination | 2.50 * | 2.15 | 2.50 | 2.57 | 2.41 | 2.32 |
| | (1.17) | (1.01) | (1.14) | (1.28) | (1.06) | (1.10) |

* - Significant difference ($p < .05$) between adjacent columns

** - Significant difference ($p < .10$) between adjacent columns

Table 5. The Expectations of Engineering Students While in the Program.

| | Gender | | | Women | | | | |
|---|---|---|---|---|---|---|---|---|
| Expectations | Women | | Men | Persisters | | Leavers | | First-Timers |
| Courseload | 4.56 | * | 4.36 | 4.59 | | 4.64 | | 4.36 |
| | (1.19) | | (1.29) | (1.22) | | (1.24) | | (1.02) |
| Career Prospects | 4.37 | * | 4.15 | 4.44 | * | 4.12 | * | 4.57 |
| | (1.14) | | (1.24) | (1.20) | | (1.08) | | (1.03) |
| Scheduling Conflicts | 4.41 | | 4.32 | 4.41 | | 4.35 | | 4.52 |
| | (1.43) | | (1.64) | (1.52) | | (1.36) | | (1.31) |
| Course Difficulty | 5.00 | ** | 4.82 | 4.96 | | 5.15 | | 4.91 |
| | (1.28) | | (1.27) | (1.24) | | (1.46) | | (1.05) |
| Length of Program | 4.68 | | 4.58 | 4.73 | | 4.53 | | 4.77 |
| | (1.24) | | (1.29) | (1.33) | | (1.11) | | (1.18) |
| Faculty Interaction | 3.25 | | 3.32 | 3.22 | | 3.19 | | 3.41 |
| | (1.32) | | (1.48) | (1.27) | | (1.42) | | (1.31) |
| Financial Support | 3.18 | | 3.32 | 3.06 | * | 3.55 | * | 2.95 |
| | (1.39) | | (1.52) | (1.35) | | (1.15) | | (1.26) |
| Peer Support | 3.78 | | 3.66 | 3.80 | | 3.63 | | 3.95 |
| | (1.30) | | (1.25) | (1.34) | | (1.30) | | (1.30) |
| Family Support | 4.24 | * | 3.92 | 4.25 | ** | 3.91 | *,+ | 4.72 |
| | (1.39) | | (1.40) | (1.46) | | (1.22) | | (1.31) |
| Social Life | 3.67 | * | 3.94 | 3.60 | | 3.74 | | 3.81 |
| | (1.41) | | (1.46) | (1.44) | | (1.35) | | (1.42) |
| Advising | 3.36 | | 3.31 | 3.44 | | 3.31 | | 3.21 |
| | (1.39) | | (1.59) | (1.40) | | (1.48) | | (1.22) |

* - Significant difference ($p < .05$) between adjacent columns

** - Significant difference ($p < .10$) between adjacent columns

\+ - Significant differences ($p < .05$) between engineers and first-timers

Table 7: Friendship Networks and College Grade Point Average

| | | Women | | | |
|---|---|---|---|---|---|
| | Men | Women | Persisters | Leavers | First-Timers |
| Friends | 7.74 | 6.69 | 7.68 | * 5.76 | + 5.66 |
| | (11.59) | (6.85) | (7.99) | 6.10 | (4.05) |
| In Engineering | 2.72 | 2.12 | 2.48 | * 1.76 | ++ 1.77 |
| | (6.36) | (2.73) | 3.20 | (2.22) | (2.04) |
| % in Engineering | 35% | 32% | 32% | 31% | 31% |
| Grade Point Average | | | | | |
| Freshmen | 2.94 | 3.03 | 3.19 | * 2.78 | **,++ 3.00 |
| Sophomore | 2.96 | 3.00 | 3.15 | * 2.82 | |
| Junior | 3.02 | 3.04 | 3.12 | * 2.91 | |

* - Significant difference ($p < .05$) between adjacent columns
** - Significant difference ($p < .10$) between adjacent columns
+ - Significant differences ($p < .05$) between engineers and first-timers