

WOMEN IN ENGINEERING AND MANAGEMENT: PROGRESS, PROMISE, AND PERCEPTION

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Abstract

In this paper we review the current, recent, and historical data associated with the representation of women in engineering and managerial disciplines, particularly focusing on the initial recruitment of women into degree programs. Beliefs women hold regarding the relative attractiveness of engineering and other careers are examined. In this paper we report work in progress using data and cases from the University of Missouri – Rolla to illustrate general findings. Specific recruiting practices and the lessons learned from them are described. Implications for employers, educational institutions, and females interested in engineering are discussed.

Introduction

Men have consistently far outnumbered women in engineering throughout the history of the discipline. These proportions in representation among the rank-and-file engineering workforce have also directly contributed to the preponderance of men in management and leadership positions in the field. Only within the last fifty years have significant numbers of American women chosen to major in engineering in college and only within the last two decades or so have normal career trajectories and developmental time spans permitted the emergence of a noticeable proportion of women in leadership positions. However, even as significant progress in proportionate representation has been made, engineering nonetheless lags far behind other traditionally male dominated fields such as law, medicine, and business in the increases in the proportion of women who have entered the discipline. Moreover, the proportion of women who choose engineering as a career seems to have stabilized in the last twenty years after a period of rapid growth in the prior decades. Thus two distinct but related problems persist: (1) recruiting more women into engineering fields at the early points of the pipeline and (2) ensuring that careers for women engineers include opportunities for managerial responsibilities.

The challenge for engineering management itself.

Increasing and maintaining gender diversity is a publicly stated goal of most organizations and professional engineering societies often sponsor initiatives to encourage more women to pursue careers

in fields in which they are underrepresented. Engineering management has a particular challenge in this regard because, while female representation in Master's degree programs in business administration (i.e., MBA) has increased markedly in the last few decades, that credential alone without an engineering degree is unlikely to provide women with greater opportunities to manage engineers and engineering processes. So increasing female enrollments in MBA programs typically would not contribute substantially to increasing their representation in engineering management specifically.

This fact compounds the challenges engineering management shares with other fields. In particular, there is a career timing problem. Many students begin MBA programs (and are encouraged to do so by business schools) only after they have 3-7 years of post-baccalaureate work experience. Whether they attend part-time or full-time, this means that traditional MBA students, particularly those who are engineering graduates, are usually in their late twenties or early thirties during the program, the prime years for having children and parenting very young children. Deferring childrearing until after the credential is obtained can be problematic as well since the first few years of the post-MBA degree career may require intense and singular attention to job responsibilities in order to advance and realize a reasonable return on the investment of time and money in the MBA degree itself.

Assuming one does not decide to defer having children until the late thirties or early forties, the alternatives strategies are to pursue the MBA immediately after one's undergraduate education or to defer it until much later when one is in one's early thirties or forties. In the former case (early start), this allows an engineering graduate to be exposed to areas (e.g., finance, marketing) in the MBA program that may entice them out of engineering even before they have begun. In the latter case (late start), it may be that one is pursuing the credential either to change careers (e.g., get out of engineering) or to advance in spite of the tremendous disadvantage that one is no longer likely to be on the managerial fast track. While there are differing legitimate views of the value of a mid-career MBA, often those who are already recognized as excellent managers won't need the credential to continue to rise, especially in engineering

organizations. Those who are viewed by upper management as having limited potential for further advancement probably won't change those opinions by obtaining the additional educational credential.

The foregoing rationale implies that the best approaches to increasing female representation in engineering generally and in engineering management specifically is to (1) enlarge the pool of undergraduate females majoring in engineering and (2) to encourage more female baccalaureate engineering graduates to start working immediately on a master's degree in a traditional engineering discipline or in engineering management specifically. The second of those two approaches has the advantage of allowing talented young female engineers to get onto a management fast track relatively early on while not foreclosing any options for pursuing an MBA (or even a doctorate) later on in their careers if they choose to do so.

Working engineering managers can contribute somewhat to recruiting women into engineering fields by participating when they can in the recruiting processes of local undergraduate engineering programs or those of their alma mater or other schools of interest to them. However, they can make a more direct and powerful contribution to increasing the retention of working female engineers in the field. The most obvious contribution is to support women (and men as well) in the struggle to balance work and family obligations. Those who are insensitive to these issues undermine progress in gender diversity even as they may be contributing to lower productivity through reduced morale, increased stress, and higher turnover rates. Our paper is focused mainly on recruiting issues but retention is equally as important.

Understanding trends and motivations. If the ultimate objectives are to significantly increase the proportion of engineers who are women and the proportion of women who are engineers, a widespread, shared, and accurate understanding of the factors that influence women's career choices is needed to develop and employ the practices that most effectively encourage them to consider and choose engineering early and remain committed to the profession. Many more women have the ability to excel and lead in the engineering workplace. Ensuring that both men and women know that and develop an interest in fulfilling that potential is the present challenge.

Numerous examinations of women in the engineering profession have chronicled their experiences and examined statistical trends (Ambrose, Dunkle, Lazarus, Nair, and Harkus, 1997; Blumenthal and Burrelli, 1999; Chang, 2002). Other authors have offered advice for female engineers and engineering students and recommendations for increasing the representation of women in the field (Bugliarello,

1971; Carter and Kirkup, 1990, Matyas and Dix, 1992, Rosser 1997; Sherwood, 1994).

In this paper we examine some of the trends and the issues associated with the current state of affairs. We discuss both empirical and anecdotal evidence for perceptions and misperceptions of the roles and opportunities available to women in the field. We also discuss some recruiting practices at the authors' institution.

Perceptions

High school and college students have certain vague beliefs about engineering and engineers: the work involves sitting in a cubicle all day doing math and everyone you work with is male. While there is a kernel of truth in these notions, representing the engineering career as a version of prison life where men do calculations instead of making license plates is a bit of an exaggeration. The diversity of responsibilities and settings in the many subfields of engineering offer a wide range of possible activities. There are many different types of engineering roles for engineers including teacher, consultant, designer, manufacturing process trouble shooter, technical representative. Moreover, regardless of role, engineering usually involves learning something new almost everyday. Thus highlighting this variety is important to changing perceptions that may discourage women from choosing engineering.

One major misperception is that women are not cut out for engineering, that they are not smart enough to do the work. While it is true that one does need a certain level of intelligence to succeed in the field, there is no evidence to suggest that males have some huge natural advantage with respect to the prerequisite levels of intellectual ability. Explanations offered for a female underrepresentation in engineering include the presence of subtle socialization processes prior to high school that may tend to bias some women away from success in mathematics and science subjects required for preparation to pursue engineering as a college major and claims of gender bias on admission tests. The extent to which these and other factors contribute to the problem remain controversial. Regardless of the causes, one result consistent with a widespread belief in gender differences in ability is that the number of women interested in pursuing degrees in business, education, pre-medical, and pre-law studies has increased much faster than the number of women interested in engineering.

Exhibit 1 shows the numbers of males and females interested in the majors listed. These numbers were compiled on the basis of responses students gave on the ACT examination taken to fulfill college admission application requirements. It is not necessarily the case that the students actually chose or completed studies in

the areas indicated. As one can see, women interested in education, medicine, and law significantly outnumber men. But, when engineering is considered, only about 20% of the total students are female.

Exhibit 1. Number of ACT Tested High School Students in the Class of 2003 Indicating Intention to Pursue Selected Career Fields by Gender

Field Of Study	Women	Men
Business & Mgmt	25,381	27,675
Education	22,770	3,626
Medicine	17,397	9,517
Law	11,472	6,980
Engineering	4,073	19,442

Source: ACT Assessment

Exhibit 2 shows the percentage of UMR females in each field. The percentage of undergraduate females in engineering is well below that of the other majors. While these results for UMR should not be interpreted as representative of all engineering programs, they are broadly consistent with the national data.

Exhibit 2. Number and Percentage of Undergraduate and Graduate Women Enrolled in Major Schools at the University of Missouri-Rolla in 2003

	Undergraduate		Graduate	
	Total	Women	Total	Women
Engineering	2859	17.2%	696	19.0%
Arts and Sciences	838	39.0%	222	27.5%
Management & Information Systems	199	28.6%	158	8.2%

Source: UMR 2003 Institutional Research & Assessment

A Brief Historical Review

According to the National Center for Education Statistics, the percentage of engineering bachelor's degrees awarded to women has grown from 0.33% in 1949-1950 to 18.23% in 2000-2001 (see Exhibit 3). As women enrolled in college in greater numbers beginning in the 1950's other barriers to their employment in traditionally male dominated fields slowly began to crumble. Simultaneously with the social changes that began in the 1960's, the expanding demand for engineers as a result of the Cold War and

the space program accelerated the pressure to increase opportunities for women in engineering. The Society of Women Engineers helped high school girls to enter college. But, nonetheless, the entry of large numbers of women into engineering was slowed in part by the parallel increase in demand for K-12 teachers as a result of the post-World War II baby boom. While barriers to women entering engineering may have started to attenuate, there were no such barriers at all to women pursuing careers as teachers. During the sixties, it was still somewhat odd for women to go into engineering; particularly because of these barriers. Teaching was considered a more appropriate option for a woman in part because it offered her more flexibility to pursue the traditional roles as homemaker and mother when she was ready to have children. In contrast, technological change in engineering fields could render obsolete the skills of a woman who took a few years off for motherhood.

Exhibit 3. Earned bachelor's degrees in engineering conferred by degree-granting institutions by sex of student: 1949-1950 to 2000-01

Year	Total	Men	Women	Women %
1949-50	52,246	52,071	175	0.33%
1959-60	37,679	37,537	142	0.38%
1969-70	44,479	44,149	330	0.74%
1974-75	46,852	45,838	1,014	2.16%
1979-80	68,893	62,488	6,405	9.30%
1984-85	95,828	83,232	12,596	13.14%
1989-90	81,322	70,071	11,251	13.84%
1994-95	78,154	65,933	12,221	15.64%
2000-01	72,287	59,110	13,177	18.23%

Source: www.nces.ed.gov

By the 1970's however, enough women had been able to overcome the traditional barriers to allow for a transition stage for their representation in the field of engineering. There were also new engineering disciplines emerging in the 1970's that possibly held more interest for women such as biomedical engineering. As can be seen in Exhibit 3, the number of bachelor's degrees in engineering awarded to women grew from a mere 330 in 1969-1970 to 6405 in 1979-80, a staggering 1941% increase! (The number of such degrees awarded to men increased over the same time period by only 142%.) In 10 years, the percentage of engineering baccalaureates awarded to women increased from less than 1% of the total to over 9% of the total!

After the 1970's though the story becomes more complicated. While the number of engineering baccalaureates awarded to both men and women

continued to climb until the mid-1980's, at that point an interesting change in the pattern occurred. The number of men pursuing engineering degrees began to drop while the number of women remained relatively stable, even increasing slightly through the 2000-01 academic year. Total baccalaureate degrees awarded peaked around 1986 and have gradually decreased ever since while the number of degrees awarded to women has continued to increase and is now at approximately the same record levels of the mid-1980's. Thus, whether one sees the situation as a glass half-empty or half-full depends upon one's reference point for comparison. Relative to their representation in other fields, women remain significantly underrepresented in engineering majors. Yet it is men who seem to be demonstrating an increasing and sustained long-term trend to choose to do something else after high school than major in engineering at college.

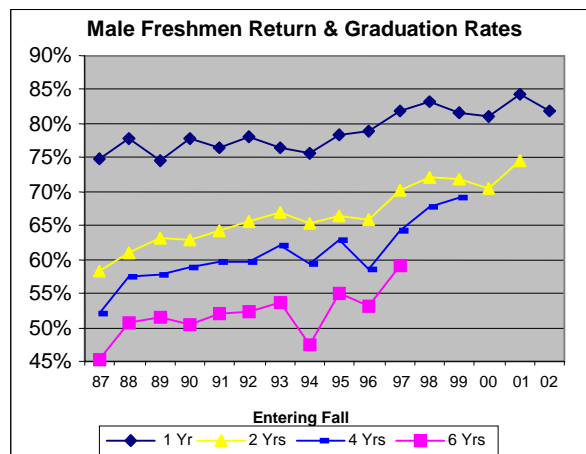
Recruiting Success Factors

If one takes the positive perspective and assumes that the numbers indicate significant success recruiting women into engineering, to what should one attribute that success? What are the secrets for recruiting women into engineering? In fact, success can be attributed to many things: breaking the original traditional social barriers, recruiting at an early age, and encouraging all women to excel in math and the sciences. One of the most important factors seems to be letting young women know that they can make it! Many universities, including UMR, offer many programs designed just for females. These include programs for females of all ages. One such event at UMR is the Society of Women Engineers Lock-In. Junior and senior female high school students are invited to UMR for an overnight stay. The women learn what it is like to be a female in a male-dominated field, what engineering actually consists of, and what the UMR campus is all about. The women are able to work on projects that show different aspects of engineering. UMR also offers summer camps designed for all students (not just females) where the students will spend several days on the campus and interact with current students. A very high percentage of girls who attend this program subsequently attend UMR (UMR Women in Science and Engineering) These programs are very successful methods for recruitment and retention. Once girls find out about engineering through these programs, a high proportion of them tend to stick with it.

At UMR, retention rates for female students generally exceed that for male students. Exhibits 4 and 5 show the retention rates for male and female freshmen. In the Fall semester of 1997, 120 full-time, degree seeking freshmen women began their UMR studies in Freshman Engineering. Of these 82 (68%) received degrees from UMR by Fall semester 2003

(after six years, which is the period of time UMR ordinarily uses to evaluate completion rates). Of these 82, 69 (84%) were in an engineering program at the time of their graduation. One should note that, during that period, many baccalaureate degree programs in engineering at UMR required a relatively high number of credit hours (in the 130-140 range) to receive a degree and many students traditionally participated in some sort of cooperative education (internship) program that often prolonged the time to graduation. This highlights one of the points made in the introduction about the timing of the pursuit of advanced degrees. Assuming that traditional first-time full-time college students are typically eighteen years of age during their first year, engineering majors in programs like UMR's may be 23 to 25 years old at graduation. Adding five years of full-time work experience before entering a full-time MBA program that lasts two years results in a freshly minted MBA who is 30-32 years old. Women at this point who have yet to have children are now approaching the end of their child bearing years at the same time that, as a new MBA graduate, they may need to demonstrate an extraordinary commitment to their jobs and organizations to advance on a management track.

Exhibit 4. Male Freshmen Return and Graduation Rates at the University of Missouri-Rolla



Source: UMR 2003 Institutional Research & Assessment

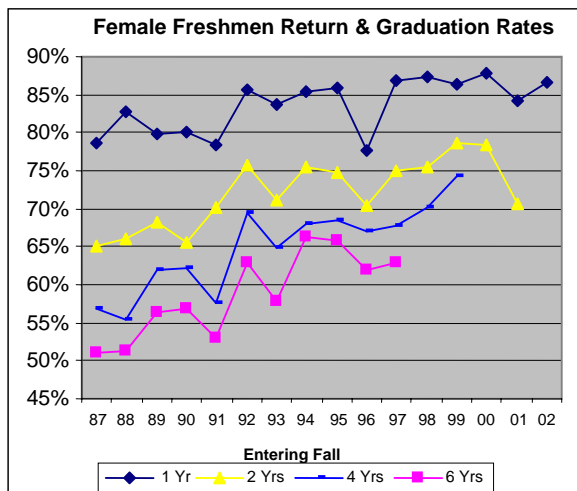
In comparison, 405 men began their freshman studies at UMR in Freshman Engineering. Of these, 243 (60%) received degrees from UMR by Fall semester 2003. Of these 243, 222 (91%) were in an engineering program at the time of their graduation. (UMR Institutional Research and Assessment 2003)

The bottom line is that women were only slightly more likely than men to switch out of engineering, and much more likely than their male counterparts to

graduate from UMR. Again, one should not attempt to generalize these data to other engineering programs. However, they do serve to indicate that, at least at UMR during the time period described, women can achieve comparable success in undergraduate engineering curricula.

But why might women come to UMR in the first place? Scholarships, including athletic scholarships, definitely can be an inducement. Another way to recruit women is to designate a strengths-based program on campus specifically for women. This program first identifies each woman's strengths and then shows her how she can use these strengths in leadership roles. Once these women are recruited, soliciting feedback and new ideas from them to foster continuous improvement is essential. Encouraging them to be actively involved in recruiting in subsequent years is also crucial. One excellent method is for them to return to their own high schools to recruit.

Exhibit 5. Female Freshmen Return and Graduation Rates at the University of Missouri-Rolla



Source: UMR 2003 Institutional Research & Assessment

Dark clouds on the horizon? Data from UMR's Office of Institutional Research and Assessment show that the percentage of high school females interested in engineering majors peaked at 20.6% in 1995. By 2002, the interest has dropped to 18%. Although only a small drop, the trend has been steadily negative for nearly ten years. While the number of degrees awarded to women increased during the nineties, that trend may be over. Women may be joining the men in seeking other careers. (Interest among men in engineering has continued to decline in recent years but possibly for different reasons.) Is this a temporary fluctuation or a more sustained trend? Is 15-20% representation a

plateau proportion beyond which additional increases become much more difficult to achieve and sustain? Time will tell but at the very least this relatively recent decline should provide even greater incentives for female engineers and engineering students as well as university officials to redouble their efforts to recruit women (and men too) into engineering.

Currently at UMR, both retention and leadership participation of women exceeds that of men. Retention of these women occurs due to many opportunities on campus. The women participate in laboratory exercises, plant trips, leadership positions, research assistantships, among many more. Once these women feel they belong to something, whether it is a sporting team, a job, an organization, or even a close group of friends, they will be more likely to want to stay. Once they decide to stay, it is the job of the university to keep them interested and to help them excel.

UMR currently has 23% female representation among its students. These women hold 40% of the leadership positions on campus. (UMR Institutional Research and Assessment) So what is the truth of about women in engineering? Women can excel. Women can lead. Women can demonstrate exceptional determination and persistence in the face of adversity. Yet it is important for female high school and college students to recognize these facts and not be misled by distorted stereotypes and maladaptive misperceptions.

Additional Steps

While progress has been made dispelling some of the misperceptions of engineering as a career, there are some unpleasant realities that act to dissuade some women (and some men as well) from entering certain fields, including engineering. One of the most important is the difficulties we have already mentioned that many working professionals have balancing work and family responsibilities. Companies and their employees must work together to help make the balance between work and family an equitable one. One way to be sure of this co-involvement is to discuss the balance at the beginning of new employment. It is necessary to ensure that both the employer and employee understand what is expected. But not only is it necessary for such an understanding to develop between employers and employees, it is also necessary for an understanding of the expectations to be shared within the family. Although these issues are there for both men and women, they can be particularly difficult for women who may bear a disproportionately heavy child-rearing and homemaking roles within a dual-career couple.

Women also often believe that if they want to start a family, this will reduce their opportunities for advancement within an organization. While this may in some cases be true, many organizations have

developed programs to mitigate adverse impacts on one's career. Flextime, telecommuting, job-sharing, parental leaves of absence are just a few of the relatively common practices in contemporary organizational life.

Conclusions

While much progress has been made toward increasing the representation of women in engineering fields, many challenges remain. The percentage of women in the field, though much higher than it was 30 or 40 years ago, is still relatively low compared with many other professions. There are signs that interest in engineering as a career is waning among both men and women. These two facts along with the evidence that appropriate recruiting and retention strategies can be very effective suggest that efforts directed at eliciting sustaining interest in engineering among female high school and college students must continue to increase. Examples of success at the University of Missouri-Rolla can help other programs facing these challenges. It is possible for many women to balance work and family life while achieving success as a professional in the field. Women can choose engineering and excel.

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