Retention of Women and Minority Engineering Educators: Is This Important to the Profession?

Norma Jean Mattei, Ph.D., P.E.
University of New Orleans

Abstract: Engineering has typically been a profession dominated by the white male. The undergraduate engineering student population, although more diverse than before, is still not reflective of the demographics of the general population. One way to attract and retain women and minority students is to have a faculty that is diverse (that also consists women and minority educators). However, there are not many women and minority engineering Ph.D. graduates, and these graduates are also courted by industry. How can these graduates be retained as engineering educators? A survey was given to a pool of tenure-track engineering educators and Ph.D. candidates who were also female and/or minority. The results will be presented in this paper.

INTRODUCTION

A quick look at the makeup of engineering faculty in the United States would find that engineering educators are not very diverse in gender or ethnicity. At the same time, many engineering programs are undergoing significant reform. The engineering educator needs to teach increasing amounts of material in a shorter amount of time, raise the student's skills to a higher level, and teach to a sometimes less prepared student population (Guice, 2001). Add to these pressures the "usual" pressures of acquiring research and funding, publishing scientific articles, service, and acquiring tenure. A graduate student finishing work on an engineering doctorate may not find that academia is a very attractive career choice. In 1997, 12% of the science and engineering doctorates were awarded to women. Blacks earned 3% and Hispanics earned almost 4% of all science and engineering doctorates. Accordingly, the pool of potential female and minority engineering educators is very small. Should it be important to the profession that these female and minority doctoral students be retained in academia as engineering educators? Why? How?

This paper will first explore one reason why it is important to have a diverse engineering faculty. Following this discussion are the results of a survey of female and under-represented engineering educators. The survey questioned these educators about the reasons that they chose engineering as an undergraduate program of study, as a graduate program of study and as a career choice.

"Proceedings of the 2002 American Society of Engineering Education Annual Conference & Exposition

The survey also questioned the female and minority engineering educators about the role that mentoring played throughout their engineering experience. As the results of the survey show, mentoring is one mechanism that can be used to retain women and minority engineering faculty.

BACKGROUND

More Jobs than Engineers to Fill Them

According to the U. S. Bureau of Labor Statistics, civil engineers held about 195,000 jobs in the U.S. in 1998. Employment of civil engineers is expected to increase faster that average when compared to all occupations through 2008. Between 1998 and 2008, the Bureau predicts that there will be approximately 78,000 openings for civil engineers, with over half (41,000) being new positions (AAES,2000). Most other engineering disciplines also expect higher that average growth in the coming years. Looking at other high-growth engineering disciplines, there are approximately 560,000 new jobs predicted for electrical engineers, computer engineers, and computer scientists. On the other hand, engineering enrollments nationwide peaked in 1983. They have since decreased by about 20%. According to the National Science Foundation, there were 392,198 students enrolled in undergraduate engineering programs in 1987 (NSF, 2000). In 1997, only 365,358 students were enrolled in undergraduate engineering programs and the trend is still downward. Nationwide, the expected increase in high school graduates is approximately 8% (WICHE, 1998). If there is an increase in engineers commiserate with the high school graduate population increase, there will still be more jobs than engineers to fill them. How will the projected openings for engineers be filled by a shrinking pool of potential students?

An Under-tapped Potential Source of Future Engineers

When you look at the makeup of the general population of the U.S. and compare it to the makeup of the undergraduate engineering enrollment, there is a well documented contrast. Table 1 shows the contrast in gender and racial/ethnic background in the population of the United States (U.S. Census 1990, U. S. Census 2000) and the population of the undergraduate student enrollment in engineering for 1987 and 1997 (NSF, 2000). Please note that the data in the second column of Table 1 for the Hispanic population in the U.S. is included in the other ethnic groups. The undergraduate engineering population has become more diverse between 1987 and 1997. However, there is still great disparity between the general U.S. population and engineering undergraduates in gender, Hispanic and African-Americans percentages. Women, African-Americans and Hispanics collectively represent an under-tapped population of potential engineers. How can we, as a profession, make engineering more attractive to this diverse source of future engineers?

Role Models

One way to increase diversity of the student population is to first have a diverse faculty. According to Kim Parker Brown, an African-American woman civil engineer, "When I was

younger, I felt that it really made a difference to be around someone who looked like me and made me feel comfortable. These perceptions were there, although my parents taught me that I should not worry about fitting in with everyone and should simply work at being the best civil engineer I could be." To a young person, fitting in and having a role model are very important. Diversity in engineering faculty is needed in order to provide all students with appropriate roll models.

Table1: General demographics versus undergraduate engineering demographics

	US 1990	US 2000	Engr. 1987	Engr. 1997
Male	48.8%	49.1%	84.6%	80.6%
Female	51.3%	50.9%	15.4%	19.4%
Caucasian	80.3%	75.1%	81.8%	73.7%
African-American	12.1%	12.3%	4.9%	6.8%
Am. Indian	0.8%	0.9%	0.3%	0.7%
Asian-American	2.9%	3.6%	8.4%	10.8%
Hispanic	9.0%	12.5%	4.7%	8.4%
Other	3.9%	5.6%	NA	NA

RETENTION OF ROLL MODELS: THE ENGINEERING EDUCATOR

The National Science Foundation, NSF, recently funded several workshops that have targeted under-represented and minority engineering educators. These workshops were designed to uncover and perhaps address problems that these under-represented and minority faculty have found in beginning their careers. The intent of the workshops was to instill in the participants a sense of belonging within a technical community in which they can succeed and make essential contributions. About one eighth of the participants were senior faculty, the rest were junior faculty in the first four years of their academic careers. Workshop participants were selected to include a broad range of race, gender, ethnic origin, technical expertise, geographic location and university affiliation.

Survey of Workshop Participants

In May of 2001, a brief questionnaire was emailed to all participants of the NSF 1995, 1997, and 1999 workshops with listed email addresses. The thrust of the survey was twofold. The author wanted to find out why this pool of under-represented and minority engineering educators chose the profession. The author also wanted to ascertain if mentoring was a factor in their education and career choices. Sixty-two participants responded. The survey is now provided.

SURVEY ON MENTORSHIP IN ENGINEERING

General

_____ 1. Your gender? A)male B)female

_____ 2. Your race/ethnicity? A)Caucasian, B)African-American, C)American Indian, D)Hispanic, E) other

_____ 3. Are you physically challenged? A)yes B)no

_____ 4. Did you attend the '95, '97' or th '99 NSF-sponsored workshop on diversity of engineering educators?
A) Yes B)No

_____ 5. If YES to above question, how did you hear about the NSF Workshop?
A)Dean, B)Chair, C)other faculty, D)organization (SWE, NSBE, etc.), E)other

_____ 6. How many faculty are presently in your dept.? A)<10 B)10-20 C)20-30 D)>30

_____ 7. How many faculty in your dept. are women/minority/physically challenged?A)0 B)1-2 C)3-4 D)>4

Engineering Education (You can select more than one, but list in the order of importance.)

_____ 9. Why did you choose engineering as an undergrad program?
A)parent or other family member is an engineer,
B)high school counselor or teacher,
C)good in math,
D)Career Day or similar contact,
E)good chance for scholarship,
F)heard it paid well,
G)other (specify)

_____ 10. If you went to grad school, why did you choose to go to grad school?
A)desire to become engineering educator,
B)desire to do research,
C)felt a undergraduate degree was not sufficient in your area of specialization,
D)other job offers weren't as interesting,
E)other (specify)
F)didn't go to grad school

_____ 11. If you are an engineering educator, why did you choose to become an engineering educator?
A)desire to teach,
B)desire to do research,
C)pioneering spirit (to fill the void in female, black, etc, engineering educators),
D)other job offers weren't as interesting,
E)wanted to impact future generations of engineers,
F)other (specify)
G)not an engineering educator

Mentors (A=yes, B=no, C=not applicable)

_____ 12. Did you have a mentor as an undergraduate student?

_____ 13. If 12 was yes, was that mentor similar to you in gender, race, etc.?

_____ 14. If 12 was yes, was that mentor an engineering educator?

_____ 15. If you went to grad school, did you have a mentor as a graduate student?

_____ 16. If 15 was yes, was that mentor similar to you in gender, race, etc.?

_____ 17. If 15 was yes, was that mentor an engineering educator?

_____ 18. Do you have a mentor as a engineer or faculty member/engineering educator?

_____ 19. If 18 was yes, is that mentor similar to you in gender, race, etc.?

_____ 20. If 18 was yes, was that mentor an engineering educator?

_____ 21. If 18 was yes, is this mentor part of a formal program at your place of employment?

Problems or Comments

Please list ANY problems associated with being an under-represented or minority engineer or engineering educator. Please list ANY comments including suggestions for improving items listed above. Your responses will be anonymous. Feel free to fax or snail mail your responses.

RESULTS OF THE SURVEY

General

Of those responding to the survey, 39 were women (63%) and 23 were men (37%). The racial/ethnic background of those responding to the survey was 34 Caucasian (55%), 11 African-American (18%), no American Indian, 11 Hispanic (18%), 4 Asian-American (6%), and 2 East Asian (3%).Only two physically challenged educator responded. Most (92%) had been workshop participants (participants had been asked to pass the survey on to other engineers). Of those, 5 had been nominated by their deans, 11 by their department chairs, 23 by other faculty members, 4 by various organizations, 3 by participants of previous workshops, and 11 nominated by workshop coordinators. The workshop coordinators used letters to deans and department chairs as their primary method of identifying potential participants yet most attendees were nominated by people other than their dean or department chair.

Now for the questions concerning faculty size and makeup. Seven (11%) of those surveyed worked in departments with less than 10 faculty, 19 (31%) came from departments with from 10 to 20 faculty, 21 (34%) came from departments with 20-30 faculty and 15 (24%) worked in departments with over 30 faculty. One (2%) respondent came from a department with no women/minority/physically-challenged faculty, 28 (45%) worked in departments with 1 or 2 women/minority/physically-challenged faculty, 19 (31%) worked in departments with 3 or 4 women/minority/physically-challenged faculty, and 14 (23%) came from a department with more than 4 women/minority/physically-challenged faculty. In general, the larger the department, the more likely there would be female or minority faculty on staff. I would like to point out that some respondents may be employed by a historically black college or university. The historically black colleges and universities may have had more representation at the workshop. This may have skewed some results regarding percentages of minority faculty.

Engineering Education and Career Choice

Tables 2, 3 and 4 show the results of the Engineering Education part of the survey. Table 2 lists the reasons that respondents chose engineering as their undergraduate program. Table 3 shows the reasons that respondents chose engineering as their graduate program. Table 4 lists the reasons the survey respondents chose engineering education as their career. Respondents could choose more than one reason.

Table 2: Why engineering was chosen as undergraduate program

Item/order of importance	1st	2nd	3rd	4th
parent or other family member is an engineer	14	7	1	0
high school counselor or teacher	3	3	1	0
good in math	24	2	1	1
Career Day or similar contact	0	4	0	0
good chance for scholarship	0	0	1	0
heard it paid well	2	3	2	0
other	17	2	1	0

Some of the reasons that respondents specified under the "other" designation include: good job with BS only, as a stepping stone to med or law school, inspired by profession, family member recommended it, friend recommended it, or supervisor recommended it.

Table 3: Why engineering was chosen as graduate curriculum

Item/order of importance	1st	2nd	3rd	4th
desire to become engineering educator	21	3	3	0
desire to do research	11	7	1	0
felt a BS was not sufficient in your specialization	22	8	0	0
other job offers weren't as interesting	4	5	1	0
other	4	2	0	1

Some of the reasons that respondents specified under the "other" designation include: flexible hours, left a problematic job.

Table 4: Why engineering education was chosen as career

Item/order of importance	1st	2nd	3rd	4th
desire to teach	33	7	1	0
desire to do research	9	20	3	0
pioneering spirit (to fill the void in female, black, etc, engineering educators)	4	4	5	0
other job offers weren't as interesting,	4	1	1	1
wanted to impact future generations of engineers	5	3	9	4
other	1	3	0	2
not an engineering educator	4	0	0	0

Some of the reasons that respondents specified under the "other" designation include: flexible hours, transfer of husband, and it was only job available in new location.

MENTORS

One approach to facilitating success in the workplace is mentoring. Mentoring derives its name from a character in the classic Greek tale by Homer in which the hero, Odysseus, entrusts his son to a loyal friend while Odysseus leaves on his seafaring adventures. This loyal friend is "Mentor", who acts as the son's teacher, counselor, advisor and surrogate father. A mentor can give advice and counsel a mentoree, although many people think incorrectly that mentoring is coaching or managing. It is additional to other forms of assistance, not a replacement (Conway, 1998). Mentoring may be either formal or informal. Formal mentoring refers to a structured program that is put in place in an organization by top leadership. Informal mentoring refers to a relationship that forms between two individuals through chance or circumstance. Perhaps the two individuals work or have worked for the same employer, perhaps they share the same profession, or perhaps they developed the relationship while in school. Because informal mentoring depends on the contacts and networking that a person develops on their own, informal mentoring has a tendency to be exclusive. Those who are under-represented within their organization may have difficulty

establishing relationships with potential mentors due to lack of access to those potential mentors. Lets take an example. In engineering education, it is safe to say that the more experienced faculty are Caucasian males. If there is no interaction (personally, professionally, or socially) between them and the junior female or minority faculty that they could be mentoring, then it is highly unlikely that informal mentoring will take place. Informal mentoring depends on some catalyst to spark the mentor/mentoree relationship.

A recent study by the Catalyst Research Group (CRG, 1998) on minority women in the general workplace surveyed 1700 African-American, Hispanic and Asian-American female managers. The study found that 22% of the women surveyed intended to quit their companies. Although most had graduate degrees, many found that they are not moving up in their corporations. Key concerns include: 47% don't have an influential mentor, 40% site lack of informal networking with influential colleagues, 29% lack company role models of the same race/ethnic group, and 28% don't get high visibility projects. What can be done to avoid this type of backlash in engineering? Remember, in the Catalyst Research Group study, the most-often mentioned key concern for minority women managers in the workforce was "not having an influential mentor".

Survey Results on Mentoring

Table 5 lists the number of those responding to the survey who had a mentor in their engineering education or as an educator. If there was a mentor, the respondent was asked if they were similar to them in gender and race/ethnicity. If there was a mentor in their post-graduate career, the respondent was asked if it was part of a formal mentoring program at their university. Most of those mentored had a mentor who was an engineering educator.

Table 5: Mentors in education, both undergraduate and graduate, and in career

	NO	YES	Similar	Similar in gender only	Similar in race only	Engineering Educator	Formal program
Undergrad	32	30	10	1	1	21	NA
Grad Student	19	43	10	1	1	35	NA
Educator	21	41	11	1	0	37	9

CONCLUSIONS

With the need for engineers increasing, women and minority high school students could be a source of future engineers. One way to a more diverse student population is to provide appropriate role models for these students. A diverse faculty would provide these role models. Thus it is important to recruit and retain female and minority engineering educators. As the number of women and minority engineering educators increase, there should be a corresponding increase reflected in the makeup of the undergraduate engineering student pool.

In order to attract women and minorities into engineering education, it is helpful to understand

why women and minority engineering educators chose engineering education as a career. The results of the survey of women and minority engineering educators provides information on the reasons that the respondents chose engineering as an undergraduate program, a graduate program, and as a career. The listed reasons for selecting engineering as their undergraduate, graduate and post-graduate curriculums and careers were as diverse as the makeup of these educators. Most of the respondents listed "being good in math" or "having a family member who was an engineer" as the reason they chose engineering as an undergraduate major. The most often cited reason for going to graduate school in engineering was "wanting to become an engineering educator" and "needing further specialization in engineering". In selecting engineering education as a career, the most often reported reason was "a desire to teach", followed by "a desire to do research", and "wanting to impact future generations of engineers".

Women and minority engineering educators themselves have few role models. One mechanism that may help retain female and minority engineering educators is mentoring. The survey asked the respondents if mentoring had been a factor in their undergraduate program, in graduate program and in their career as engineering educators. As undergrads, less than half of those surveyed had mentors. Two thirds of the respondents had mentors as graduate students, with a greater number of those mentors being engineering educators (perhaps their Ph.D. advisor?). Again, two thirds had mentors in their careers as engineering educators. Most of those mentored as engineering educators (+75%) were not part of a formal mentoring program at their university. Across the board, these mentors are generally not similar to those surveyed in gender or race. This is probably because most of these mentors are senior engineering faculty and most engineering faculty are white males or male non-US citizens.

It was surprising to the author that more than half of the women and minority engineering educators surveyed reported having mentors. Perhaps this may be a survival mechanism. In other words, in order for these under-represented engineering educators to succeed, they develop mentor/mentoree relationships with a trusted advisor (who may or may not be an engineering educator themselves). Because the survey targeted women and minority engineering educators and did not include the general engineering educator population, it is not known if a similar percentage of white male engineering educators also have mentors. Of those responding to the survey who did report having a mentor during their career as an engineering educator, most were in informal, rather than formal, mentoring relationships.

In closing, the survey also allowed respondents to list problems and comments associated with being a female or minority engineering educator. Problems cited most by those women and minority engineering educators who responded to the survey include:

- more service work than other faculty (which is not rewarded for in tenure and promotion)
- feeling isolated
- not being part of the network
- not being taken seriously as a instructor/researcher

The advice of a trusted mentor may eliminate or reduce some of the problems listed by the survey respondents, especially "feeling isolated" or "not being part of the network". Teaching institutions may want to develop formal mentoring programs for young tenure-track faculty in order to facilitate retention of these desirable under-represented faculty.

REFERENCES

American Association of Engineering Societies, *Engineers,* Vol. 6 No 1&4, Publication of the Engineering Workforce Commission, Washington D.C., 2000

Bureau of Labor Statistics, U.S. Department of Labor, Occupational Outlook Handbook, 2000-2001 Edition

Catalyst Research Group, *"Minority women in the workplace."* The Associated Press, Times Picayune, Section C, February 10, 1998

Conway, Christopher, Strategies for Mentoring. John Wiley and Sons Publishers, New York, 1998

Guice, Leslie, *"Challenges & opportunities in engineering education"*, ASCE, The LA Civil Engr., Journal of the LA Section, Volume 9, No.3, May 2001

National Science Foundation, "*Report: women, minorities and persons with disabilities in science and engineering: 2000"*, 2000

Western Interstate Commission for Higher Education, *"Knocking at the college door: predictions for high school graduates by state and race/ethnicity, 1996-2012"*, 1998

U.S. Census Data, United States and State of Louisiana: Orleans and Jefferson Parishes, Database, 1990

U.S. Census Data, United States and State of Louisiana: Orleans and Jefferson Parishes, Database, 2000

NORMA JEAN MATTEI is an associate professor in the Civil and Environmental Engineering Department of the University of New Orleans. She teaches structural engineering analysis and design classes. Her research areas include diversity, experimental structural testing and materials testing, engineering ethics and design procedures in the maritime industry.