Recruiting and Retaining Women in Agricultural and/or Biological Engineering

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Abstract

Recruiting and retaining women into agricultural engineering has been a long-standing challenge. The newer biological engineering oriented curricula appear to be attracting more women into the departments which have initiated such programs. Louisiana State University reported in the April, 1993 issue of Within ASAE that of the 81 students enrolled in their Biological Engineering program, 41% are women, compared to approximately 10% in typical engineering classes.

We surveyed female graduates of six midwestern agricultural engineering departments to better understand their reasons for choosing Agricultural Engineering, and to learn of their experiences as students. This article will discuss the survey results, and also present findings from other studies related to the recruitment and retention of female students in engineering.

Why do women choose Agricultural Engineering as a career choice?

An easier question to answer is why don't women major in science and engineering in general? Eleanor Baum, Dean of the Nerken School of Engineering at The Cooper Union for the Advancement of Science and Art in New York City, contends that one of the major reasons people do not enter engineering is a lack of understanding of what engineers do (Baum, 1992). She feels that recruitment material should be written not necessarily by an engineer, but by people who understand how to motivate high school students. The recruitment material should include females, not just in the photographs, but also in the text. Gender-specific language has been found to alienate potential female students.

Another deterrent Baum cites is that engineers project the image that you have to be a genius to be an engineer, particularly if you are a woman. She finds this very upsetting, because she sees average males in engineering and yet women who enter the field tend to be outstanding high school students, who are very confident individual leaders. A report by the Council on Academic Excellence for Women (CAEW, 1991) agrees that the perception is only superwomen can succeed in engineering. The perception is reinforced by the lack of female faculty in engineering departments.

Add to this perception the socialization that women receive throughout life which teaches them to be averse to science (CAEW, 1991). Female teachers in math and science are not plentiful, and Brush (1991) states that "most women who teach mathematics in elementary school convey to their students a sense of their own lack of competence in the subject". The result, Brush contends, is that negative factors tend to feed on one another, so that a lack of women in the field tends to perpetuate a lack of women in the field. He noticed that when women scientists are featured in mass-circulation magazines they are often portrayed as "atypical scientists and atypical women". American culture has a long tradition of anti-intellectualism, and scientists are portrayed a nerds, but, as Brush points out, even nerd is not a genderless noun; the scientist is understood to be male.

Whereas men typically carry a socially-imposed burden to succeed, and are highly encouraged by their families and society to do so, women are seen by society to be free to "choose" other options besides a successful career. Indeed, the socialization women receive directs women toward choosing a "nurturing" career or life choice. Engineering is typically seen as an inanimate science, and as such is not consistent with the life values of many women. Perhaps Biological Engineering is recruiting more women than the traditional Agricultural Engineering because the new curriculum is seen as more consistent with female socialization.

Some women do choose engineering as a career, and they tend to have some common characteristics. Baum (1992) found more than two-thirds of these women have a family member who is an engineer, typically either a father or a brother. Baum interprets these results to mean that "to know what engineering is about you have to know an engineer who is a positive role model". In a 1991 report in the Ohio Journal of Science, Bellisari interviewed female graduate students, 18 of which were humanities majors, and 17 who majored in science and engineering. The engineering and science majors cited relevance to social concerns, occupational opportunities, high incomes, and professional prestige as reasons for selecting their careers. Eight of the 17 were influenced by male teachers or relatives, and eight others mentioned both parents as influential in their decision. The encouragement included discussing science subjects with the students, in-

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cluding the young women in science-related activities, and encouraging them to enroll in a science-oriented major. Students who succeed in science and engineering tend to be highly motivated and have a good support system behind them.

Survey Participants

We surveyed 80 graduates from six midwestern universities and obtained an 83% response rate. Ninety percent of the respondents were in the 20-35 year age bracket, 9% were in the 36-55 year age bracket, and 1% was in the 56-65 age group. Ninety-seven percent were caucasian, 1.5% were african-american, and 1.5% were asian-american. Their pre-college backgrounds were diverse, as can be seen in Figure 1. Five of the respondents hold a Ph.D. in Agricultural Engineering, 21 have Master of Science degrees, and 35 hold Bachelor of Science degrees as their highest degree obtained. One graduate obtained a DVM degree, and three hold MBA's. The years since graduation from the undergraduate program is generally normally distributed, with the mean falling in the 6-10 year range. The majority of the female graduates specialized in Soil and Water. However Figure 2 indicates that the technical specialties of female graduates span the spectrum of specialties.

Recruitment

The survey asked the graduates why they chose Agricultural Engineering as a major in college. The questions had multiple choice answers, from which the respondents could select multiple answers, so responses reported total to more than 100%. Forty-eight percent indicated that they chose Agricultural Engineering because they like math and science, and had a rural background. Twenty-six percent were interested in environmental issues and Agricultural Engineering offered a technical specialty in this area. The pre-Vet option attracted 6%, and 9% of the female graduates were directed to Agricultural Engineering by parents or a counselor. Thirty-eight percent thought the Agricultural Engineering curriculum offered more diversity than the other engineering majors. Twenty-nine percent indicated "other" as a reason for selecting this major, and the reasons given ranged from an interest in specialties offered like food engineering or solar energy, to liking the smallness of the Agricultural Engineering departments. Several respondents thought that Agricultural Engineering dealt more with people and natural resources than other engineering majors. These graduates knew when they chose Agricultural Engineering that they enjoyed math and science, and some indicated an interest in applying the engineering to living things, such as people and the environment.

The survey respondents offered suggestions on recruitment, which support the ideas presented above. One graduate suggested that "even more important than having [women] enroll in a technical major at the college level, however, is to expose [girls] to hands-on, fix-it type experiences at a much younger age. Practical experience is so important, in my opinion". This statement supports the idea that females are socialized to dislike science, but with positive intervention, girls could discover that science is fun and that they can succeed in science. Science (1993) has an excellent article discussing the early intervention in science education of girls.

Another recruitment-related comment received on a survey response was as follows: "I think that, in general, students do not know what engineers are and what they do. Communicating with students through brochures, at career fairs, and one-on-one seems effective. I still remember the brochure about Food Engineering that got me interested in the program. Then, luckily, the department head spent time with me, telling me about Agricultural Engineering. Once I was enrolled in the program, I looked to upper classmates to tell me about the curriculum, and later, about the job opportunities. Perhaps math, chemistry, or biology majors would be a good target group to contact. These people [may] have [an] interest in engineering, but [need to see the] *application.*" This graduate recognizes that students generally do not know what engineers are, but good recruitment material would be effective. Also, she stressed the importance of the time the department head spent with the student, underscoring the importance of encouragement and support of the non-traditional student. She also suggests recruiting from math and science departments, because these students are interested in science, and may be interested in engineering if they see the application to biological systems.

Retention

Once a student has decided to enroll in Agricultural/Biological Engineering, they can take two paths. They can continue in the major and graduate, or they can leave the department, either to change majors, or to leave college. Our survey addressed the first group, and asked questions to try to determine what their college experience was like. These results will be reported below. It is more difficult to gather information on the students who leave the department prematurely, however several studies have addressed retention of women in engineering, and some conclusions from these studies will also be discussed.

Active support and encouragement of female students has a positive impact on retention, as will be discussed in the next section. We asked these graduates what type of support system was available to them as undergraduates. Eight of the respondents reported that the engineering college encouraged women to participate in mentoring programs, and one person reported that her department had organized support for female undergraduates in the department. Only one graduate reported that female role models were available to her in the department. The lack of female faculty has been cited in many studies as a problem in recruiting and retaining women. The majority of graduates reported that no formal support was available, but they had faculty and students offering encouragement. Eight others said their department did not support women, and in one case the person commented that "My fellow students were very supportive of me as well as some faculty, but there were a few faculty who made it known that they didn't want me in their classroom. I was referred to as

the 'Little Engineering Girl'." If a new student encountered a non-supportive faculty person early in her tenure, the student is more likely to believe the faculty person is right than to believe in herself. It has been shown in several studies (Arnold and Demy, 1985; CAEW, 1991; Brush, 1992), that women are less confident in their abilities than male students, even when the female's abilities actually exceeded that of the male students. Add to this the fact that the female is in a traditionally male curriculum, and may be receiving negative messages from society (Why would you want to be an engineer?), and it is easy to see why an instructor's attitude can strongly influence the student's likelihood of remaining in the program. Active support from the instructor is often needed to counteract the negative influences the female is encountering from some of the students, faculty, friends, and families.

When asked whether or not they would select Agricultural Engineering again as a major if they had it to do over again, most of the respondents said yes, because of the diverse curriculum, the camaraderie of a small department, and the challenging program in Agricultural Engineering. Several responded no, mainly because they had difficulty finding desirable employment because the employers did not understand Agricultural Engineering.

In general, the females who graduated from agricultural engineering departments were positive about their experience, yet retention of women is a problem for many departments. In fact, retention of women in science programs in general is a challenge. The CAEW report (1991) states that research data show that women leave science in significantly greater numbers than men with comparable ability. Brush (1991) reports that the number of American women who earned science and engineering degrees increased steadily from 1960 through 1980, then unexpectedly reached a plateau. A recent report in Science magazine (1993) discussed the "leaky pipeline" for women in science and Baum (1992) states that the dropout rates for women in engineering schools is very high.

A common misperception is that the women leaving the program are inadequately prepared. This is not true in general, however. Several studies (Arnold and Demy, 1985; CAEW, 1991; Brush, 1991) report that even when the actual abilities of women in college were equal to or exceeded that of their male counterparts, the women dropped out at a much higher rate. In a study of male and female high school valedictorians, all entered college with confidence in their intelligence. Self-estimates of intelligence in the women declined sharply during the second year of college even though they were still receiving good grades, in most cases better than the males, who still had strong self-estimates of their intelligence. Brush (1991) reported that "during college, according to many reports, women students who are apparently well qualified and strongly motivated, lose their self-esteem, are harassed by male professors and students, are excluded from crucial discussions and social interactions, and in general are made to feel that they do not belong". The CAEW (1991) reports data that show undergraduate and graduate women have significantly lower self-esteem and self-confidence about scientific performance than men of comparable ability and performance level. The study found that women are much more likely than men to attribute difficulties to their own imagined deficiencies rather than external factors. Brush further states that "as scientists and educators, we find it particularly difficult to admit that discrimination against women persists in our disciplines. We would like to believe that the barriers that once existed have been removed, but the statistics are not kind to this belief". He states that over the past two decades overt discrimination has become covert, but it's still effective.

Some of the attitudes of professors and students which may inhibit females succeeding in engineering include: preconceived notions about the seriousness of women's commitments; negative judgements of women's qualifications based solely on gender; and the difficulty of developing the social side of professional relationships because of rumored romantic attractions. These problems are exaggerated when the faculty or students are from cultures where women are not respected.

But even when no perceived discrimination exists in the classroom, Betz (1989) contends that women are still at a disadvantage in relation to their male counterparts. She contends that a null environment, which is an academic situation which neither encourages nor discourages women, is inherently discriminatory because it fails to account for the differentiating external environments from which men and women come. The student's life outside the classroom directly affects how a student will perform in the classroom. Betz has found that men are typically encouraged to remain in engineering, even if their academic performance is not outstanding, whereas women are typically questioned by their friends and families as to their motivation for studying engineering, even if they are outstanding students. Since females are continually receiving social messages that they do not belong in engineering, unless they are actively encouraged by their professors to remain in this field, the tendency is to change to a more accepted field of study. Many of the messages female students receive are very subtle, in fact Bellisari commented that "many parents and teachers are unaware of the environmental forces that discourage and/or exclude women from scientific study", but they are real nonetheless.

Placement

We asked the graduates specifically about their first job search upon graduation. One-third reported having an easy time finding a job, 27% thought the process took longer than they would have liked, 20% had a difficult time, and the remaining 20% did not look for a job and/or went on to graduate school. Several respondents reported being told by their departments during recruitment that since they were female they would have an easy time finding a job, but over half of the graduates did not find this to be true. The graduates also reported having been told they could expect higher salaries because they were female, however only 10% of the respon-

dents found this to be true. Sixty percent reported salaries similar to their colleagues, and 30% reported lower salaries.

Making Progress

So how can we encourage female students to remain in our programs, and help them to feel that they do belong in agricultural/biological engineering? The first step is to become aware of the various areas in the classroom where subtle messages are being sent to the women students. For example, in laboratories, do the groups form such that the men tend to operate the equipment and perform the experiments, while the women record data and write the reports? This scenario builds the men's self-confidence with handling equipment and erodes the women's self-confidence. The women (and other students who lack a mechanical background) may be hesitant to operate equipment if they have not been exposed to the equipment previously. But if a non-threatening situation can be set up, where these people can gain some experience with the equipment without being ridiculed for their lack of expertise, then they will be much more likely to perform the experiments during class. Another common problem found in scientific classrooms was that the instructors had more eye contact with the men than the women. This was true regardless of whether the instructor was male or female. Also, the male students were praised in front of the class for having good ideas, whereas the women were praised for having neat papers. Actions such as these send messages to the female students that they are not valued members of the class. The student hears that their value comes from being neat and not from their intelligence.

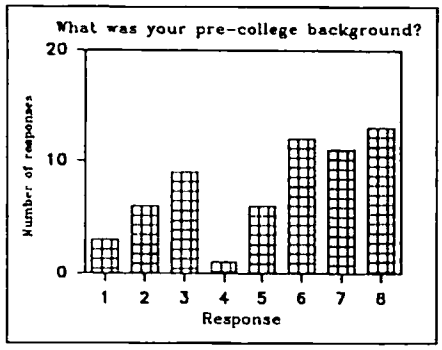

Figure 1 Pre-college background of female agricultural engineers.

The response numbers correspond to the following:
1. farm (1000+ acres)
2. farm (500-1000 acres)
3. farm (100-500 acres)
4. farm (5-100 acres)
5. non-farm rural
6. small town
7. city
8. major metropolitan area

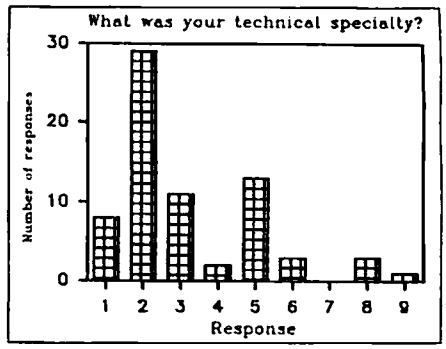

Figure 2 Technical specialties of the female graduates surveyed.

The specialties are as follows:
1. Power and Machinery
2. Soil and Water
3. Structures and Environment
4. Electrical Power and Processing
5. Food Engineering
6. Pre-Vet
7. Biological
8. I was not an Ag. Eng. undergraduate
9. Other

Another improvement to the classroom would be to eliminate teaching methods which encourage memorization and rapid problem solving, because these methods discourage intuition and creativity. The computer age enables people access to information, and we need to encourage people to think creatively. Men and especially women respond more energetically to subject matter that has been put into the context of helping people or the environment. Curriculum should demonstrate social value and practical application, not just be presented in a technical manner.

The CAEW report lists 18 activities that discourage women, and hence practices that academics should avoid. They are:

1. Treating women as social acquaintances rather than as competent professionals by focusing on appearance or personal qualities rather than accomplishments.
2. Devaluing women because they speak softly or hesitantly but criticizing them if they speak aggressively.
3. Evaluating women negatively much more than men when women are critical of others rather than comforting.
4. Giving female faculty and graduate students heavier teaching and service responsibilities than men.
5. Giving more attention and offering more independent study opportunities to men than to women.
6. Avoiding or insulting women professionals and students, more often notice by men from other cultures.
7. Reacting more often to women than to men with scowls.
8. Using women's first names but men's surnames.
9. Interrupting.
10. Ignoring a woman's presence.
11. Hesitating to discuss a women's project or research.
12. Asking women specific rather than higher order open ended questions.
13. Faulting a woman in a group dominated by men for not being assertive, but faulting a woman as not feminine or abrasive when she is too assertive.
14. Allowing sexual innuendos and jokes without remonstrating.
15. Maintaining a nonsupportive (null) teaching environment.
16. Maintaining an exclusively competitive, non-collaborative teaching environment.
17. Ignoring research potential of undergraduate women.
18. Avoiding or limiting positive interaction with students seeking course selection advice and career advice or assistance with course work.

The main message that was apparent in all the studies reviewed was that positive reinforcement must be used in the classroom. Apparently sex-neutral practices and failure to act are perceived as discouragement to women. Retention can be improved by talking with the female students and telling them that they are a valued member of the department. In addition, it would be informative to periodically survey the female students to find out what it is like to be a female student in your department, and report these findings back to the entire faculty. Female students have much to contribute to the agricultural/biological engineering profession, and we should be actively recruiting women into our programs. But recruitment is not enough; our departments need to understand that many female students are coming from different backgrounds than the traditional agricultural engineering students, and we need to be prepared to provide a supportive environment so that they too can learn.

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Proposed Constitutional Amendment

For action at the 1994 Annual NACTA Business Meeting, a proposed amendment to the NACTA Constitution, adding to **ARTICLE III., a Section 10** which follows:

Graduate Student Membership. Graduate student membership in NACTA shall be available to graduate students, particularly teaching assistant, in agriculture disciplines who pay annual membership dues. These members shall have all voting privileges but shall not be eligible for awards available to members in other membership categories. However, graduate student members shall be eligible for such awards as designated by the NACTA Executive Committee for their membership category.