

A Survey of Biological and Agricultural Engineering Female Faculty in North America

Stephanie Cauble
Louisiana State University

Ann Christy
Ohio State University

Marybeth Lima
Louisiana State University

Abstract

While females make up approximately 19% of college graduates receiving B.S. degrees in engineering, they account for less than 3% of engineering faculty positions in North America (Trautner 1996). One discipline that is overcoming some of the barriers of this leaky pipeline is Biological and Agricultural Engineering (BAE), in which women comprise approximately 7% of the faculty. We designed a confidential survey for this group based on personal and academic history, career issues, and opinions and experiences. Our goals were to identify factors that have led to the success of these women faculty, and to make recommendations to better integrate women into all engineering disciplines. Results (based on a 53% response rate) showed that BAE departments provide a supportive environment, and that the female undergraduate student population is 40% or higher in 65% of the BAE programs. The majority of respondents reported that gender discrimination was not a job issue, and believe that the attraction of women to BAE is due to its emphasis on biological systems, as well as BAE's newness and lack of long-standing stereotypes of male dominance. Recommendations are to increase mentoring at all levels of education and work and to increase networking of female faculty within universities.

I. Introduction

Nationally, women comprise approximately 19% of B.S. engineering graduates, 10% of engineers in industry, and 3% of faculty in engineering departments. The faculties in Biological, Agricultural and related¹ Engineering (BAE) programs in North America are approximately 7% female. Because this percentage is more than double the national average across all engineering disciplines, we believed that studying this group of women might yield valuable information about the environment of BAE departments and factors that might be linked to the higher percentage of women in this discipline. By studying women at the faculty level, we hope to gain insight into the environments they encountered during their undergraduate, graduate, and faculty careers. A review of current literature shows that a survey of all women faculty in a discipline of engineering regarding personal and professional issues has never been conducted.

Several studies which have targeted the retention of women in engineering academics have examined the conflict between women's success in academics and their family role. Brush (1991) suggested that the structure of tenure and promotion which requires large amounts of time and stress during the first segment of a professor's career overlaps with her childbearing years, so that a woman is forced to choose between raising a family and pursuing an academic career.

Nokes and Gustafson (1994) examined the motivations of female graduates of six Midwestern agricultural engineering departments for choosing their major, and discussed issues of recruitment and retention of female students in engineering. They found that women were attracted to this major because of an interest in math and science, the diversity of the BAE curriculum with respect to other engineering disciplines, and an interest in applying engineering to living things. Forty-eight percent of the respondents came from a rural background.

A study by Hawks and Spade (1998) examined attrition rates for women in engineering from both a gender differences perspective as well as a role conflict perspective. They found that the anticipation of balancing work and family was one of the major barriers to women's pursuit of engineering in general or of prestigious and demanding jobs within engineering. They suggested that the fulfillment of a professional role conflicted with the traditional family obligations for women while it complemented the family role for men. While gender differences may have played a role in their decision to enter engineering, these men and women students already in engineering programs had similar motivations and interests toward engineering, as well as equal preparation and abilities. Culotta (1993) determined three factors as integral to women's success in the engineering field: the number of women currently employed, the age of the program or industry, and the

¹ Also includes Bioresource and Biosystems Engineering. Most Biological Engineering departments were originally Agricultural Engineering departments.

attitude of the specific workplace. She suggested that networking and mentoring are the areas in which women most often face disadvantages in engineering fields.

Our objectives were to survey faculty on their motivations for choosing engineering, their personal and professional experiences, and their reflections and opinions regarding women in engineering, and to make recommendations to better integrate women into all engineering disciplines.

II. Materials & Methods

A 47-item survey was designed to evaluate the demographics, academic history, work and family issues, career issues and perceptions of female professors in Biological/Agricultural (and related) Engineering (BAE). A list of 67 North American schools with BAE departments was determined from the 1996-1997 ASAE roster. Female professors were identified from this list by phone calls to the department and by information provided by schools' websites. The survey was sent out by email to 60 candidates. Although the number of women surveyed is small, it represents the entire population of women BAE faculty, rather than a select sample. Those who did not receive the email survey were sent a hard copy of the survey. Reminders were sent periodically over email. All results were recorded in an Excel file. Thirty-two responses were received for an overall return rate of 53 percent.

III. Results & Discussion

Demographics

Eighty-six percent of the respondents are tenure-track professors. Figure 1 shows the titles and ages of the respondents.

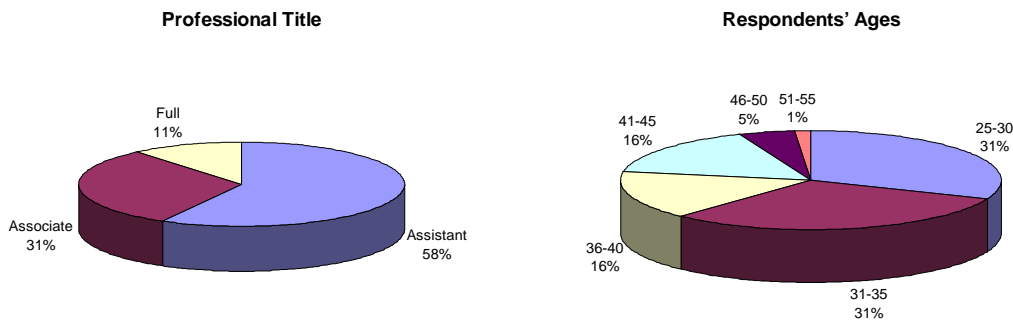


Figure 1: Titles and Ages of Respondents

Fifty-eight percent of the respondents were assistant professors; this correlates with corresponding ages of respondents, as 62% are age 35 and younger.

Their B.S., M.S., and Ph.D. disciplines vary, although the most common discipline for any degree level is Agricultural Engineering. Figure 2 shows the percentages of female undergraduate and graduate students enrolled in the respondents' departments.

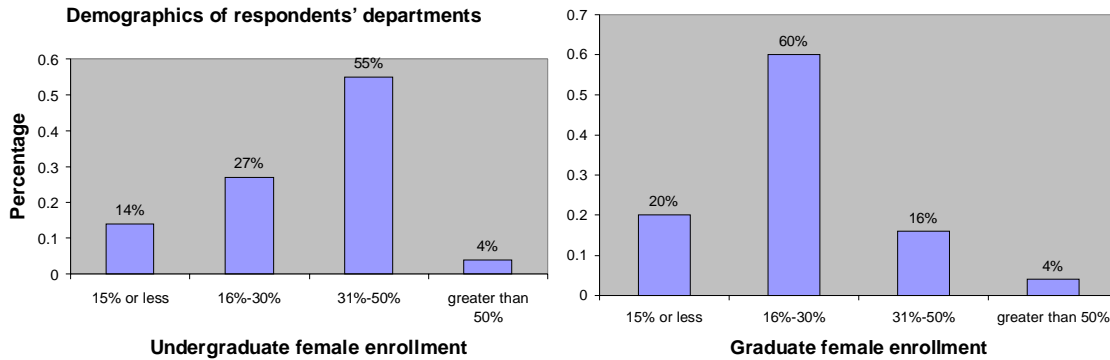


Figure 2: Female undergraduate and graduate enrollment in BAE departments

Figure 2 demonstrates the phenomenon often labeled the “leaky pipeline,” a low persistence of women in higher education and across all disciplines of science, engineering, and mathematics (Benditt, 1993, Brush, 1991, Rosser, 1990). The percentage of undergraduate female students is greater than the percentage of graduate female students, which is in turn greater than the percentage of female professors. While women make up 7% of the BAE faculty nationwide, graduate enrollment is encouragingly high, and undergraduate enrollment is between 31 and 50%. Although the pipeline exists, it is skewed upward with respect to national averages across all disciplines.

Academic History

The survey asked respondents to rate the factors which influenced their decision to enter engineering based on a scale of zero to four in which zero indicated a “not at all” importance and four denoted “very important.” Forty-seven percent of respondents reported math/science ability as “very important” as a factor for entering engineering and 50% gave this ranking for math/science interest. At the opposite end, 56% of respondents reported that counselor encouragement was “not at all” important in their decision to enter engineering; 7% noted being discouraged from entering engineering either because they were female or because the profession of engineering was viewed as not “people-oriented.” Thirty-one percent rated the influence of a role model as “not at all” important in their decision to enter engineering. Survey respondents also offered suggestions for encouraging more women to enter engineering. One respondent stated that “the under

representation of women in engineering is not a retention/climate issue once they are in an engineering program. It's a pipeline issue of getting them in. The remarkable increase in female enrollment in BAE says to me women are interested in biology/life science fields."

In an open-ended question, survey participants were asked why they chose to pursue a Ph.D. Their responses are shown in Figure 3.

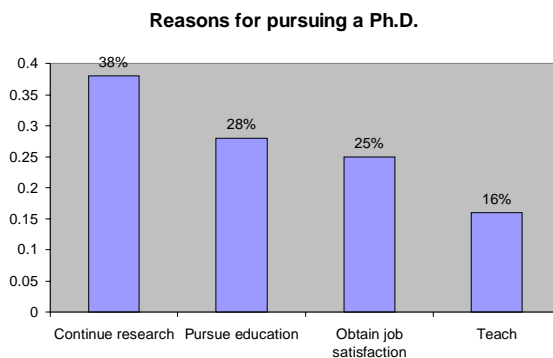


Figure 3: Most common reasons for pursuing a Ph.D.

When asked if they had ever felt incapable of achieving a Ph.D., 69% of respondents reported that they had not. A follow-up question asked how they had maintained confidence in themselves on the job. The following responses were given:

- *"I am not always confident, but neither are the male professors I know. We all do a lot of bluffing."*
- Another maintained confidence by *"Being insensitive to bad as well as good experiences."*
- *"At this point, I am not sure that I am very confident. I am holding onto the idea that I must be doing something right because people are still asking me to do things."*
- *"It has been difficult to maintain confidence at times. It seems that admitting any mistake or error at all causes (male) colleagues to think much more poorly of one than of a male counterpart. I do not know if my perception is completely accurate. I work at an outlying experiment station that now has a 'critical mass' of women faculty from several agricultural/food science disciplines. It has been beneficial to have colleagues who can validate (or not) one's perceptions."* She identifies the importance of having a gender balance in order to discern whether instances of gender bias are real or perceived.
- *"I was very confident in my abilities until the last few years. After 20 years as an engineer, I have discovered that I cannot 'succeed' in engineering at a level that I thought I could. I feel I have finally hit the 'glass ceiling' my ability to succeed is not dependent on my ability to do the work, it is rather dependent at this point on being*

part of the 'old boys network.' Unfortunately, to be part of the 'old boys network', I have to do all the work that no one else wants to do. Otherwise, I am excluded."

Another respondent pointed to this as a subtle form of discrimination: *"as a woman, it is much harder to get into the 'communication stream.'"*

Career Issues

The survey asked respondents to compare their teaching/service requirements to those of their male counterparts. Sixty-five percent of respondents reported having duties equal to their male counterparts, 27 percent reported having more, and 8 percent had fewer. A disproportionately high teaching load is listed as one deterrent to the success of women in engineering; it is encouraging to note that almost three-fourths of those surveyed to not suffer from this problem. Several written comments are listed below.

- *"more teaching, less high profile or important responsibilities, but more low profile or less important service"*
- Another respondent who reported having "more" teaching/service responsibilities than her male colleagues added, *"It's a token female thing."*
- *"equal now that our departmental chair has changed."*
- Another "equal" respondent added that she did not do resident instruction and *"several female students have lamented the fact that we have no female teaching faculty."*
- *"equal or more depending on how long they have been around. The older they are around here the less they do."*

The survey asked an open-ended question about the biggest sources of stress for the respondents. Thirty-eight percent listed problems related to a lack of communication and faculty support structure; 25 % said they had too little time; and 22 % listed having too many responsibilities. A follow-up question asked whether or not these sources of stress were gender-related; 65 % said that they were not.

Several respondents linked their service responsibilities to gender. Comments on job-related stress are listed below.

- *"I am asked to sit on numerous committees, attend meetings, review documents, etc. Many of these service requests are gender related. The group wants a woman to participate and not many are available."*
- *"lack of recognition"*
- *"inability to work on things that are important to me"*
- *"lack of good mentoring by senior faculty. I don't think older men can help me overcome some of my worries because they can't relate. I have really wanted a woman to talk to about some things, and I have women friends who are untenured faculty just like me, and that is where I get some of my best support and 'mentoring.'"*
- *"an individualistic entrepreneurial approach to research instead of a more team-oriented multidisciplinary approach contradicts my more collaborative (female) bent."*

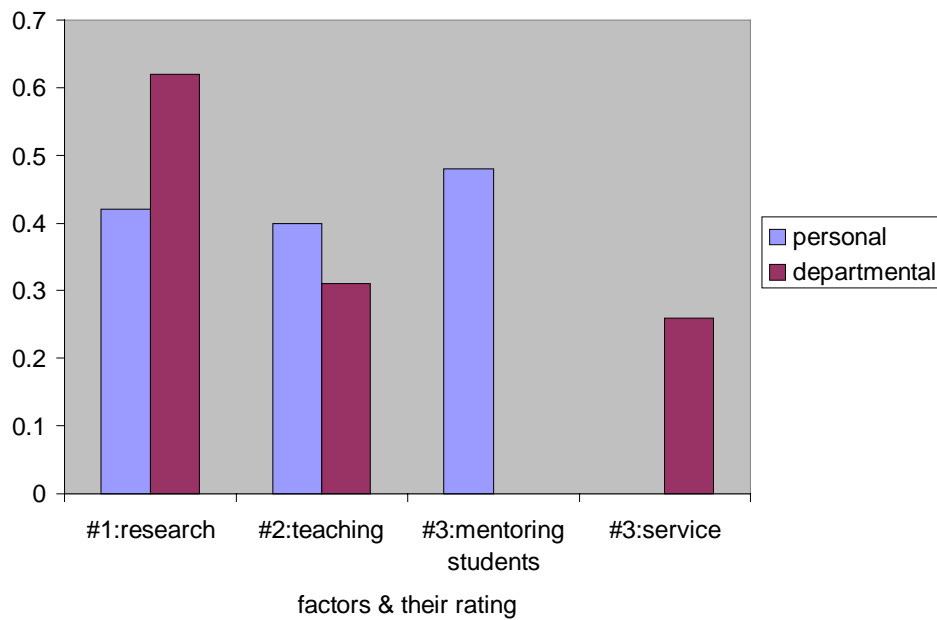
Survey participants were asked to rank on a scale of zero (never) to four (always) how often they experienced discrimination at undergraduate, graduate, and present environments. At each level, the most common response was two (sometimes). The experiences of respondents ranged from “*overprotective attitudes on the part of male supervisors*” to serious instances. One respondent said, “*Discrimination in grad school nearly made me drop out of my program—having an outstanding advisor/mentor prevented this.*” Another respondent shared the following experience: “*One professor during my Ph.D. coursework publicly embarrassed me. I immediately dropped the class, and the rest of the students in the class wrote a letter to the dept chair complaining about the professor although most of them stayed in the class. He did not teach any more courses to students directly on campus although a place was found for him training international visitors. He is well respected for the work he has done, but I will never use any of his research or books in my teaching.*” Both of these responses show an immediate reaction of “dropping out” when faced with discrimination, a response which has been shown to discourage some women from pursuing engineering. Both responses also point out the existence and importance of a support structure within the academic environment which was able to keep them from leaving engineering. Research has identified a correlation between support structure and minority issues and it appears that BAE has this structure in some instances. This may be one factor in explaining higher percentages of women students and faculty. A sampling of comments is listed below.

- “*I realized that my salary was the lowest in the college, my teaching load was disproportionately high, my salary coverage was only 5.2 months from the department (I was covering my salary from research), my assignments were typically ‘female’ (labs, seminars, etc) and there was no maternity leave for women in engineering, and promotion and tenure decisions were not being made on a timely basis. (I was an assistant professor 10 years after my Ph.D., an inordinate amount of time.) I filed on EEOC suit which was subsequently settled. However, as of this summer, the department and college have not (in my opinion) fulfilled the intent or letter of the agreement. As part of the agreement I changed my home department to Civil Engineering; I am now only a joint faculty in Agricultural Engineering.*”
- “*I have not perceived any active discrimination against me as a woman; however, I probably have a thick skin when it comes to this issue.*”
- “*I don’t think gender has had much at all to do with my career or life experiences. I have never let it get in the way of doing what I wanted and no one has ever prevented me from doing what I wanted.*”
- “*I have been in engineering for 25 years and have not seen a lot of substantial changes in that time. I think the ‘ceiling’ has perhaps been raised a bit (from undergraduate to a higher level for working women engineers); however, it just takes longer to hit it. I am convinced that the only way to change the environment and opportunities for women is when there is a critical mass of women at each level. I think this will happen. I am personally discouraged because it won’t happen soon*”

enough to make my career as rewarding as I would like. However, I think it will happen for those who are younger than I am.”

- *“I have had many gender related issues that hindered my career. Many of these issues have disappeared due to change in management. I have also learned how to voice my concerns. I strongly suggest that women find gender friendly places to work. I feel that only a few men are against women in the work force, and some men treat all people badly at all times. Women should learn to see the difference between the two types. Work somewhere where women are treated differently only if necessary to do a short term job. At the same time do not refuse work because of a fear of the unknown.”* The last comment addresses some important issues: women need to recognize the difference between unfair treatment which is gender-based and unfair treatment which is not. Also, that it is important for women to learn to take responsibility for voicing their concerns. Lastly, that it is often necessary to seek out an environment in which women are already accepted.

One question asked participants to rank the factors of administration, mentoring faculty, mentoring students, outreach/extension, research, service, and teaching according to their personal priorities and according to the values of their department. For personal priorities, research was most commonly ranked as the top priority with 42%, teaching most commonly ranked second (40%), and mentoring students was most commonly ranked third by 48% of respondents. For department priorities, 62% ranked research first, 31% ranked teaching second, and 26% ranked service third. The figure below depicts this data. It is interesting to note that women perceive the importance of research and teaching in an almost 1:1 ratio while they perceive that the administration is interested mostly in research (2:1). Also the departure of perceived importance of the university and service activities contrasted what respondents thought were important, especially with regard to mentoring. Fifty percent of respondents ranked mentoring faculty as the lowest priority of their department, although only 17% ranked this as their lowest priority personally. One respondent explained her rankings as follows: *“#1 for research because we are a research university; #7 (lowest rank) for mentoring faculty because faculty ‘training’ is not viewed as a university function.”* Another respondent said, *“There is a big push to get outside contracts, research monies; there has been little attempt to mentor students & faculty.”* Both of these respondents point out that while departments are demanding more of their faculty members, they are often not providing a formal structure for the guidance from which these faculty members could benefit. Another respondent said, *“I have never been assigned a mentor by my department and no efforts have been made by anyone (other than the merit/review process) to provide feedback on my performance.”*



When asked if they acted as a mentor themselves, 58% responded that they did, whether through formal or informal programs. One respondent said, *“Mentoring hard-working students is wonderful. It is one of the best parts of my job.”* Another responded that she tried *“to mentor newer faculty when appropriate.”* Other respondents reported mentoring students as young as high school age through summer programs held on campus. One respondent said, *“I advise a large percentage of both undergraduate and graduate women in the department. Women in my class seem to seek me out to discuss both personal and professional problems. These range from unwanted pregnancies to difficulties with advisors to incidences of harassment.”*

Work & Family

Respondents also pointed out that inequalities in the workplace were often due to external factors in the home.

- One respondent said, *“Men either with kids or no kids have magic wives at home to support them. I don’t so I have to do so many more things. Men with magic wives move through the ranks quicker because they can devote themselves entirely to the job.”*
- Another said, *“Despite the fact that most of my male colleagues have at-home or part-time working spouses (or no kids) they are considerate of the issue. Some are genuinely interested in how it all gets balanced!”* Both point out that commitments at home often affect a female professor’s work.
- One respondent offered another suggestion: *“Choose a spouse/partner wisely if one wants help with the childrearing! Mine is very involved with the children; perhaps more than I am.”*
- Another respondent commented, *“It is exhausting to raise a family and have a heavy professional career. It is definitely a man’s world. I did not feel it as much during my two postdocs, but now as a faculty, I feel it a lot.”* One respondent linked family issues directly to discrimination: *“Job evaluation at the university level is done on male criteria. For example maternity leaves are to be taken at your own risk.”*

Perceptions

Ninety-six percent of respondents felt that the number of female engineers in school, academics, and industry should increase. Following are some comments given.

- *“I don’t think the environment and acceptance of women in engineering (either students or faculty) will improve until there is a critical mass. Nothing else seems to make a difference. Women have to change the environment themselves and that takes a group not isolated individuals.”*
- *“More role models are needed; better environments are generated by diverse populations.”*
- *“At the very least, the percentage of female faculty should be similar to the percentage of female students.”*
- *“Numbers are part of the answer but a focus on numbers is too simplistic.”*
- *“There are many types of jobs/careers. It’s more important that women are interested in what they do.”*
- *“I don’t think gender is the issue. Performance is the issue. Quality instruction needs to increase, regardless of gender. Women may be more willing to include wholistic approaches to engineering.”*

Respondents were asked to give their opinions in essay format on why BAE was attracting and retaining more women compared to other engineering disciplines, and also to provide any suggestions for integrating women into all aspects of engineering. Some responses follow.

- *“Areas where there is a higher percentage of women engineers usually are related to somewhat of a nurturing, healing, or caring type technology such as environmental, biomedical or food” sciences.*
- *“Show them the positive aspects of engineering careers, particularly the changes in many disciplines (e.g. stronger ties to human factors, biological systems).”*
- *“BAE is light duty.”*
- *“Girls become familiar with chemistry biology and the environment in high school. I believe this helps them make a connection with biological, chemical and environmental engineering. This is not the case with physics and ME, CE and EE.”*
- *“More women are interested but scared by the image, the math requirements, even if they are able to take the load easily. Give confidence to younger women so their goals are more ambitious. Change the image of the engineer by having more contacts between engineers and the greater public. Dedramatize the importance of exact sciences like math and physics which require hard work but no inhuman skills to master.”* She points out that the image of engineering may deter girls from considering the field while their abilities may be adequate. She stresses the importance of interaction between engineers and the public in general in demystifying the image an engineer’s work.
- *“We need more contact with girls in grade school and junior high to encourage them to pursue degrees in engineering. More contact is also needed at the high school level to ensure students are aware of the many exciting opportunities in mechanical,*

electrical and civil engineering as well as in biological and chemical engineering.” She points out the importance of exposing students to engineering at an early age. She also notes that, as students progress, their awareness of engineering needs to encompass a variety of fields, with an understanding of the opportunities specific to each field.

- *“Increased mentoring on all levels.”* This response echoes that of earlier questions which cited mentoring as important in respondents’ successes in engineering at the undergraduate, graduate, and faculty levels. She said that after women enter engineering as undergraduates, *“make sure they are part of a group of other women students; hire more women faculty and then encourage interactions by officing them near each other, etc.”*
- Another reason often given as to why women enter BAE was that it is *“an emerging field with fewer perceived stereotypes.”*
- One respondent listed the following advantages: *“Smaller departments, (more faculty contact, more of a sense of belonging), more biological emphasis, more gracious and mutually supportive students, less of a male-dominated reputation to overcome (this is the one time it’s helpful not to be an immediately recognizable engineering field such as mechanical, civil, etc), BAE departments have to work harder to recruit their students (of either gender) so they appreciate them more.”*

Bibliography

1. Benditt, J., editor. 1993. Gender and the culture of science. *Science* 260: 383-430.
2. Brush, S.G. 1991 Women in Science and Engineering. *American Scientist*. 79: 404-419.
3. Erickson, L.R. 1981. Women in Engineering: Attitudes, Motivations, and Experiences. *Engineering Education*. pp. 180-182.
4. Nokes, S.E. and Gustafson, R.J. 1994. Recruiting and Retaining Women in Agricultural and/or Biological Engineering. *NACTA Journal*. pp. 49-53.
5. Rosser, S. 1990. Female friendly science: applying women’s studies methods and theories to attract students. Pergamon Press. New York, NY.
6. Trautner, J.J., Chou, K.C., Yates, J.K., and Stalnaker, J. 1996. Women Faculty in Engineering: Changing the Academic Climate. *Journal of Engineering Education*. 85: 45-51.