Gender Equity in Industrial Engineering: A Pilot Study

BETTY J. HARRIS, TERI REED RHOADS, SUSAN E. WALDEN, TERI J. MURPHY, REINHILD MEISSLER, and ANNE REYNOLDS

We report on findings from a pilot study focused on the Industrial Engineering Department at University of Oklahoma where gender equity has been achieved. The study identifies factors that may contribute to gender parity in engineering and science fields.

Keywords: gender equity / engineering education / women in engineering / industrial engineering

Although female university students outnumber males at the undergraduate level, and in recent years there has been an increase in university women faculty and administrators, many science and engineering fields continue to have low numbers of women. A notable exception is the Industrial Engineering (IE) Department at University of Oklahoma (OU). As of fall 2003, 50 percent of the IE undergraduate majors were female (compared to 25 percent nationally), while 40 percent of the faculty were women (compared to 10 percent nationwide, Table 1). In order to carefully examine, understand, and compare this successful case of gender equity in an engineering field, we applied for and were awarded a National Science Foundation (NSF) Gender Equity Program grant (Award NSF-GDSE #0225228).

This report of preliminary findings is from a pilot study conducted prior to submission of the NSF grant proposal. We interviewed 11 students and alumni to assist us with a research design to identify factors that contributed to gender parity in IE at OU. In the three-year funding period (2003–05), we plan to interview students in IE and other engineering and science departments at OU and, subsequently, at Arizona State University, the University of Pittsburgh, and the University of Nebraska–Lincoln.

Two existing works helped us develop our study. Elaine Seymour and Nancy Hewitt (1997) conducted an ethnographic study of seven four-year institutions of higher learning to identify factors leading to students switching out of the sciences, with an emphasis on women and minorities. They also examined the transition of both genders from high school to college. Seymour and Hewitt (1997) found very few gender differences between the motivations of switchers and nonswitchers. In illuminating the reasons why females chose science, mathematics, and engineering majors, they suggested that young women tend to be put under pressure by the professional parent, usually the father (Seymour and Hewitt 1997).

They found that young women's career orientation is often not as strong as young men's, but young women try to please significant others in their lives, including parents and teachers, through good performance in mathematics and science in high school (1997). Seymour and Hewitt also pointed out that aspects of female socialization are incompatible with the "competitive ethos of science" (1997, 234).

Margolis and Allan (2002) focused on one case study, the highly ranked School of Computer Science at Carnegie Mellon University. They examined differing gender perspectives on computing in elementary and high school to provide a context for analyzing a pronounced underrepresentation of female computer science majors at the university. They discovered that fathers are more involved with computers, thereby encouraging the interest of their sons during pre-college years, and that home computers are frequently under male control (Margolis and Fisher 2002).

To attract female students, Margolis and Fisher (2002) suggested that computer science not be embedded solely in science and mathematics, that its social relevance and practical applications be considered, that more concerted efforts be made to recruit women and minorities not simply on the basis of high test scores and grades, and that more intense faculty-student interaction be encouraged. By modifying admissions criteria, the Carnegie Mellon School of Computer Science was able to achieve greater diversity while continuing to admit qualified students.

Our study builds on the insights and combines the methods of Margolis and Fisher (2002) and Seymour and Hewitt (1997). The case study of the IE Department at OU provides a lens through which we will examine the status of women in other science and engineering departments at the University of Oklahoma and industrial engineering units at other universities.

Culture of Industrial Engineering at OU

In studying the culture of an academic department, three main groups need to be considered: the faculty, the students, and the administration. Although this study began with the students in the IE department, it has become apparent that the faculty and administration played a significant role in determining how gender parity was achieved.

The Department of Industrial Engineering at the University of Oklahoma has 10 full-time tenure-track faculty. At the time of the pilot study (spring 2002), four of the 10 were women. Compared with the national percentage of female faculty, the IE Department is four times the national average (Thorsen et al. 1998). Table 1 summarizes statistics related to this project.

Table 1
Proportion of Women in Selected STEM Fields Fall 2000

Participating Departments	OU Students[b]	Students Nationwide[d]		OU Faculty[e]	Faculty Nationwide	
IE	47/84	55%	25%	4/10	40%	10%[f]
Chem E[a]	126/325[c]	39%	33%	1/15	6%	8%[f]
Mathematics	24/75	32%	46%	3/29	10%	19%[AMS]
Physics	16/75	21%	20%	4/28	14%	8%[g]
CS[a]	46/312	15%	24%	2/12	17%	11%[h]
AME[a]	45/338	13%	12%	1/15	6%	6%[f]

[a] "Chem E" is Chemical Engineering; "CS" is Computer Science; "AME" is Aerospace and Mechanical Engineering.[b] OU Provost's web page, Fall 2000 data, left column is women/total. [c]Chem E at OU includes material science.
[d] U.S. Department of Education (2000), *Table 257.—Bachelor's, master's, and doctor's degrees conferred by degree-granting institutions, by sex of student and field of study: 1997–98.*
[e] Obtained by consulting department personnel; left column is women/total; includes tenured and tenure-track only.
[f] Thorsen et al. (1998), *Appendix D: Data on Faculty Rank Comparing Georgia Tech to Benchmark Schools, 1998.*
[g] Ivie and Stowe (2000), *Table 4. Percent of Faculty Positions in Physics That Were Held by Women, 1998* (includes full, associate, assistant professor, and other ranks).
[h] Bryant and Vardi (2002), *Table 21. Gender of Current Faculty* (includes full, associate, and assistant professors in CS and computer engineering departments that grant Ph.D.s).

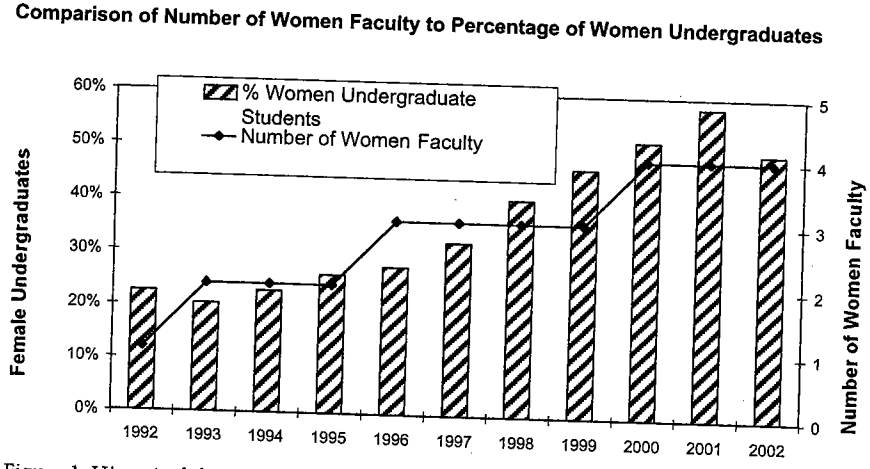

Figure 1. Historical data from the Department of Industrial Engineering at OU

Beginning in 1996, which happens to coincide with the hiring of the third female faculty member, the number of women undergraduates in the IE Department began climbing by 6 percent per year, starting at 28 percent. This steady increase reached its pinnacle in 2001 when the department achieved its highest proportion of women students—58 percent (Figure 1). It should be noted that the overall number of students has also increased from 1998, when the department was at a low of 80, back to its 1995 high of 120 students. The department is not considered large in the total number of students.

The department's physical location is unique in comparison to many other departments or institutions. The majority of the faculty offices are located in a single sub-hall, off the main thoroughfare in one of the engineering buildings. Within the sub-hall, the majority of the faculty offices are situated behind the desk of a single office assistant, who is student friendly and always welcoming. This assistant typically knows the approximate whereabouts of the faculty and shares with students ideas of how best to contact individual faculty members. Typically, office doors are open while faculty are working on various projects, not just during their office hours.

Faculty value the quality of the undergraduate students and frequently use their talents in research environments. By their junior year, students often are invited to join research projects as research assistants during the academic year or in the summer. In addition, faculty tend to communicate not only formally with students (e.g., discussing course content, requirements, etc.) during class time and office hours, but also informally during social events and outside office hours.

Pilot Study and Data Analysis

The pilot study included personal interviews with six female undergraduates and two alumnae, and two male undergraduates and one alumnus, all randomly selected. All participants were nonswitchers (out of IE). Two undergraduate interviewees completed their degrees.

This analysis considers women students' perspectives on the Industrial Engineering (IE) major and provides comparative data from male students. An approximate ratio of one male to two females represents an undersampling of males. Additional data were gleaned from summaries and field notes.

All IE majors and alumni highlighted positive aspects of the major. The general consensus among interviewees was that males and females are not treated differently in the IE major at OU.

Student Backgrounds

With regard to their family backgrounds, female undergraduates interviewed in the pilot study were relatively new to the IE major and were aware of that fact. Only two female undergraduates had parents with an engineering or other STEM (science, technology, engineering, and mathematics) background and these were fathers, not mothers. Contrary to Seymour and Hewitt's (1997) findings, women in our pilot study, for the most part, relied on their mothers to give them guidance regarding their undergraduate education.

Female students attended very good high schools by national standards. Most seemed to have had a well-rounded science curriculum. One was a National Merit Scholar and two others also indicated being scholarship recipients at OU.

Both male undergraduates were traditional students. One switched from Petroleum Engineering, the field of his father, to IE. The other student, a National Merit Scholar and the son of a computer programmer, was recruited into IE from high school and remained in the major. The alumnus, from a family background in which both parents had service jobs, also switched to IE from Petroleum Engineering.

Computer Use

On average, female undergraduates in the study were exposed to computers later than male interviewees, ranging between late childhood and adulthood. The male range was between early childhood and early adolescence.

Teaching and Learning

Most of the women were aware that there were more females in their IE classes than in other core engineering courses. One female student remarked enthusiastically about her satisfaction with being in a class with equal gender representation in which the professor was also female. In addition, two female undergraduates described themselves as visual learners, as did the two alumnae.

Of the two male undergraduates, one indicated that he liked the classroom to be an active learning environment in which he could be communicative and engaged in hands-on activities. He enjoyed participating in study groups. The other male student liked the availability of the faculty to discuss more complicated topics.

Participation in Funded Research Projects

The pilot study data showed that only two of the eight female interviewees were involved in a funded research project. However, anecdotal evidence indicated that a sizeable percentage of female students were involved in such projects.

The two male undergraduates were more vocal about their participation in funded research and its future impact on their careers as engineers. However, the alumnus did not indicate that he was involved in a funded research project.

Perceptions of the IE Major

All female undergraduates interviewed liked industrial engineering's people orientation, which requires good interpersonal communication and writing skills, and its practical applications and management potential. Most were involved in study groups with their classmates and in student organizations. The two male undergraduates indicated an interest in aspects of management.

Perceptions of Students of the Other Gender

Female students expressed few reservations about relationships with male students. However, one female observed that despite her high grade-point average, she still had to prove herself. Having had to compete with male students from other engineering majors in some of her courses, she noted that on several occasions, some male engineering students have mockingly called IE "imagineering" or imaginary engineering. For her, the denigration of the discipline compounded other perceived sexist behavior. This type of behavior, which seems to be exhibited only seldom in IE, is viewed as contributing to a negative atmosphere for women in science nationally (Seymour and Hewitt 1997).

Both male undergraduates were aware of the fact that about half of IE majors are female. One attributed women's attraction to IE to its being a "softer" science, as well as to the department having a number of women on the faculty. The other male commented that the "50–50 split" between genders in IE is the exception in the College of Engineering.

Students' Future

In their concern to make a smooth transition from academic life to working life, one female student planned to pursue a Ph.D. and teach, while others were contemplating jobs in industry. The department offers cooperative arrangements and internships to give students the opportunity to work in an industrial setting. One female student had participated in a co-op.

One male undergraduate planned to attend graduate school while the other considered employment possibilities and, eventually, graduate school. A company employed the alumnus where he was an undergraduate intern.

Conclusion and Recommendations

Our pilot study found that female majors perceive IE at OU as having a very receptive environment. The department has a proportionately high number of female faculty members and provides intense faculty-student interaction in different settings as compared to the more limited interactions typical in science and engineering described by Seymour and Hewitt (1997). Although the women have similar preparation as their male counterparts, they do not have the family ties to STEM fields as do the males in the pilot study. In the case of male students, fathers not only provide guidance and expertise, but also ideas about career options. The mothers who inspire female students seem to provide moral support but have no substantial knowledge of the field, its demands, and its possibilities.

Female undergraduates are actively involved in study groups as are their male counterparts. However, for the most part, they do not discuss their involvement in funded research projects.

Departmental culture seems to play a role in creating an ambience that is comfortable for female students. The type of culture and to what extent it affects students will be one of the future foci of the NSF-funded project that resulted from this pilot study. Certainly, the University of Oklahoma's industrial engineering case study provides a positive model for female undergraduate recruiting and retention in STEM majors nationally. We will identify additional contributing factors as we engage in more intensive ethnographic study in IE, in other University of Oklahoma science and engineering departments, and at several other universities.

Based on our preliminary findings, we have a few recommendations. Since the use of feminist pedagogies is implicit in this successful example of gender parity in IE (e.g., hands-on experiences, internships, cooperative projects), they should be made more explicit, and become a component of faculty pedagogical retooling to the benefit of students of both genders. We also recommend that advising have a strong career-planning orientation, particularly for female undergraduates. Finally, the pilot study suggests that even in a situation where the numbers of women and men are equal, sexism is not totally absent. Hence, efforts have to be made to recognize and deal with the more subtle forms of gender inequality.

Betty J. Harris *is women's studies director and associate professor of anthropology at the University of Oklahoma. A past president of the National Women's Studies Association, she is author of* The Political Economy of the Southern African Periphery: Cottage Industries, Factories, and Female Wage Labor in Swaziland Compared, *as well as several articles and book chapters. Send correspondence to Harris at Women's Studies Program, Physical Sciences Center 530, 601 Elm, University of Oklahoma, Norman, OK 73019; bharris@ou.edu.*

Teri Reed Rhoads *is director of engineering education for the College of Engineering and assistant professor in the School of Industrial Engineering at the University of Oklahoma. Her research interests include learning in the engineering classroom and recruitment and retention of majors. She can be contacted at teri.rhoads@ou.edu.*

Susan E. Walden *is director, Research Institute for STEM Education at the University of Oklahoma. Her research interests include diversity in STEM education, improving the appeal of and entry into STEM fields, and gifted education. She can be contacted at susan.e.walden-1@ou.edu.*

Teri J. Murphy *is an associate professor in the Department of Mathematics at the University of Oklahoma, with research specialty undergraduate mathematics education. Her primary research interests are in the area of diversity and equity in science, engineering, and mathematics. She can be contacted at tjmurphy@math.ou.edu.*

Reinhild E. Meissler *earned a diploma in Religious Studies from the University of Bremen (Germany) and received her Ph.D. in anthropology from the University of Oklahoma. Her primary research interests are eco-anthropology, social change, and religion. She can be contacted at reinhild.e.meissler-1@ou.edu.*

Anne Reynolds *is associate professor in Instructional Leadership and Academic Curriculum at the University of Oklahoma. Her research interests focus on mathematics education and elementary education. She can be contacted at areynolds@ou.edu.*

References

Bryant, Randal E. and Moshe Y. Vardi. 2002. *2000–2001 Taulbee Survey: Hope for More Balance in Supply and Demand*. Washington, D.C.: Computing Research Association. http://www.cra.org/statistics/survey/01/01.pdf.

Ivie, Rachel and Katie Stowe. 2000. *Women in Physics, 2000.* College Park, MD: American Institute of Physics. http://www.aip.org/statistics/trends/reports/wominphys.pdf.

Margolis, Jane, and Allan Fisher. 2002. *Unlocking the Clubhouse: Women in Computing.* Cambridge: The MIT Press.

Seymour, Elaine, and Nancy C. Hewitt. 1997. *Talking About Leaving: Why Undergraduates Leave the Sciences.* Boulder, CO: Westview Press.

Thorsen, Carolyn, Donna Llewellyn, Marion Usselman, and Anne Balsamo. 1998. *InGEAR (Integrating Gender Equity and Reform): Report on the Status of Women.* Atlanta: Georgia Institute of Technology.

U.S. Department of Education. 2000. *Digest of Education Statistics.* Washington, D.C.: National Center for Education Statistics.