An Examination of Technical Interests Motivating Women and Men Engineering Majors

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In a 1993 study of the persistence of sex segregation in education, Meece and Eccles stated that in the US parity had been achieved in college enrollment for women, but

> *"there was only a slight reduction in the amount of sex segregation found in courses of study selected by women. Women continue to dominate many traditional female fields, such as education, library science and foreign languages. The most significant changes have occurred in law, medicine, business and architecture. Women have made significant advances in science, mathematics, and engineering, but are concentrated heavily in life science, social sciences, and psychology."* [6]

Figure 1 illustrates the significant changes in various fields for the percent of those graduating receiving Bachelor degrees who are women. While the change in women's representation since 1967 is significant, it is interesting to note that engineering has only recently reached the representation level where physical sciences were in the late 1970s, and still has not reached the levels of biological and agricultural sciences prior to 1967 when many overt barriers to women were being removed. Within these trends, there are significant differences for various fields of engineering, as there are for various fields of sciences.

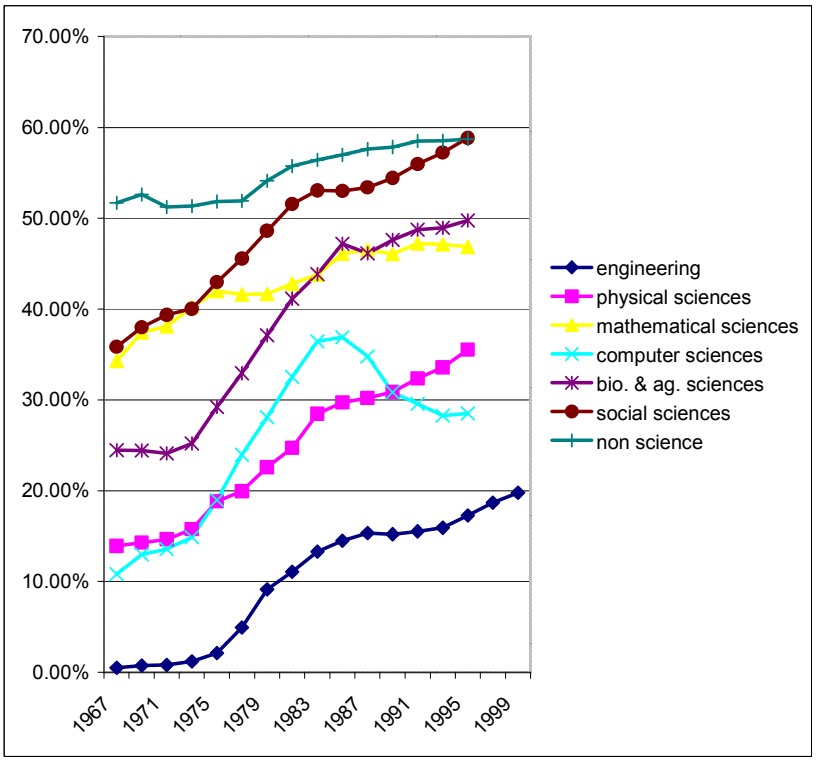

Figure 1 Percentage of Bachelor Degrees Awarded to Women in the U.S. [7]

Looking at Table 1, the representation of women receiving Bachelor degrees in Engineering in the US in 2001 ranges from as high as 33.75% in Chemical Engineering, and as low as 13.21% in Mechanical Engineering. [7] (The range for Biomedical and Environmental Engineering will probably be even higher, but the national data was not available from this source.) In examining these data, it is easy to understand conclusions by Holdstock in 1998 when he stated:

> *"Although for various reasons the ratio* [of men to women] *may change without social manipulation, for example the ratio for seven branches of engineering changed at a fairly constant rate from about 4 percent in 1980 to about 12 percent in 1994* [in the UK], *it is possible that each change converges towards a limit, as may be the case for psychology, and if experience of the United States is a guide, these seven branches of engineering, as an average, may have a limit not much above the present value."* [4]

In this conclusion, Holdstock was considering the Bachelor graduates in the fields of Aeronautical, Chemical, Civil, Electrical and Electronic, Mechanical, Production, and General Engineering between 1981 and 1993 in the UK. Holdstock goes on to state that he knows of no psychological discussions of why differences exist in the representation of women between different branches of engineering.

Table 1 Percent of Bachelor Degrees in Engineering Fields Awarded to Women [7]

	1994	1995	1996	1997	1998	2000	2001
Engineering	16.51%	17.28%	17.93%	18.40%	18.61%	20.52%	20.11%
Aerospace	12.66%	12.99%	15.04%	15.66%	15.80%	18.78%	20.29%
Chemical	29.86%	31.67%	32.36%	32.62%	32.67%	35.42%	33.75%
Civil	18.71%	20.28%	20.11%	21.39%	22.36%	24.31%	22.81%
Electrical	12.34%	12.34%	11.83%	12.28%	12.33%	13.30%	13.84%
Industrial	29.37%	29.16%	29.43%	27.00%	25.58%	33.20%	32.06%
Materials	21.70%	23.61%	22.21%	24.37%	23.34%	27.57%	28.28%
Mechanical	11.39%	11.23%	11.96%	11.84%	12.24%	13.61%	13.21%
Other	18.80%	19.03%	21.25%	21.14%	21.75%	25.62%	27.09%

The reasons for the persistence in gender segregation in some fields of study are complex and not well understood. This is because, while representation of women in a field is a snapshot of large numbers of people present in the field, the actual path to choosing a field of study is unique to each individual. Feingold examined the results of numerous studies on the differences in intellectual abilities between men and women and could draw the following conclusions [2]:

1. Men score higher than women on general intelligence tests, mechanical reasoning, and mental rotation.
2. Women score higher than men on language usage and perceptual speed.
3. No significant differences are found between men and women in abstract reasoning, arithmetic, memory span, spatial visualization, and verbal ability.

Even the places where differences occur, little is gained in explaining the persistence of gender segregation in some fields. One viewpoint, derived from the works of Holland [5] and Gottfredson [3], combines the perception of field prestige and gender perception to understand the complexity of career choices. However, Dunnell and Bakken [1] found

that adolescent girls are more willing to cross perceived gender lines for careers than are boys.

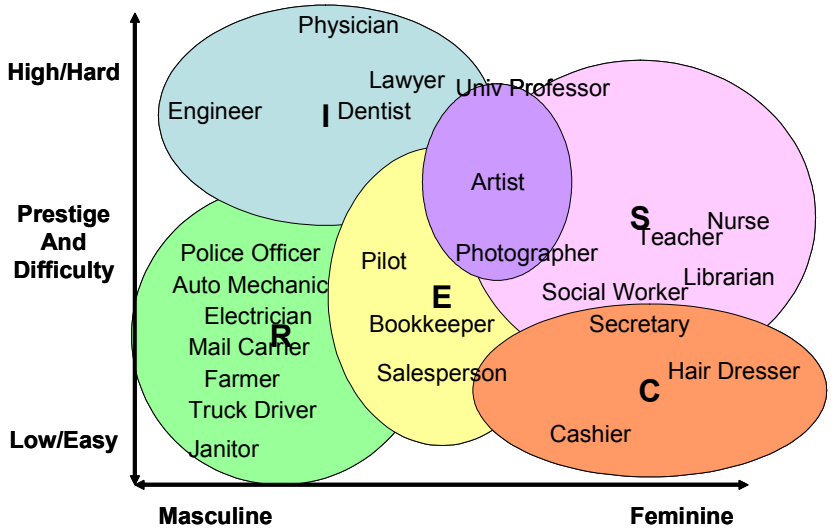

Figure 2 Distribution of Career Choices According to Prestige and Gender Perceptions

In this paper we opted to look at the patterns of choices on presentation topics made by women enrolled in a junior-level class in Mechanical Engineering, to see if we gain any deeper insights concerning what we may need to do to avoid the Holdstock conclusion that we may have reached a limit on the representation of women in engineering. Table 2 shows the representation of women receiving B.S. degrees in various fields of engineering in the 2001/02 academic year (the last year for which we found national data). Mechanical Engineering at Texas A&M University falls in the same general range as the national average for women receiving B.S. degrees in ME.

Table 2 BS Degrees Received by Women at Texas A&M University and ASEE National Data in 2001/02 and 2002/03

	TAMU			National	
	2001/02	2002/03	2003/2004	2001/02	2002/03
Engineering	22%	22%	22%	21%	20%
Aerospace	23%	34%	21%	18%	19%
Chemical	37%	31%	35%	37%	38%
Civil	17%	21%	18%	24%	23%
Electrical	10%	13%	14%	15%	15%
Industrial	38%	40%	36%	36%	35%
Materials	no UG	no UG	no UG	29%	30%
Mechanical	14%	12%	14%	14%	15%
Other	29%	21%	27%	25%	19%

It is interesting to note that in the departments shown in Table 2 for 2001/02, Aerospace had no women faculty members; Mechanical and Industrial had two women faculty members; Chemical and Electrical had three women faculty members; and Civil had four women faculty members. In contrast, the undergraduate advising offices for these

departments all had women and men involved in academic advising, except in Civil and Electrical where there were only men.

We examined the presentation topics chosen by students enrolled in the Mechanical Engineering course 381, seminar in mechanical engineering, which is a required course for all ME majors. This course normally is scheduled in the second semester of the junior year; however, its only prerequisite is upper-level status in ME. Upper-level status is obtained when a student has completed the required first-year courses in engineering, mathematics, physics, chemistry, and English with the appropriate grades for entry into the major (currently 3.0 for ME majors). The course description is given below. It is most common for the students in this course to have completed engineering science courses in statics, dynamics, electricity & electronics, and materials, as well as ME courses in design, fluids, mechanics analysis, materials & manufacturing, and dynamics & vibrations. Controls and heat transfer courses may have been completed by some of the students. At Texas A&M University, the ME department had only one tenure/tenure-track woman faculty member and she has been on professional leave working at a national laboratory for the past two years. Thus, it is unlikely that any of the students involved in this study have taken a course from a woman ME instructor. Beginning with the fall semester 2004, this condition changed significantly since three of the six newly-hired tenure-track ME faculty members are women. Within the College of Engineering, of the 47 new tenure/tenure-track faculty hired for the fall 2004, 11 (23.4%) are women.

COURSE DESCRIPTION:	Preparation of two written papers and two oral presentations on mechanical engineering topics; generation of a professional résumé; development of a life-long learning plan; presentations by different faculty and industry representatives on: effective communications, preparation for engineering practice, becoming a professional engineer, contemporary issues, engineering ethics, career-long technical competence, the impact of technology on society, and being well-read and well-informed. One Credit (1-1). Prerequisite: Upper level ME standing.

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In the MEEN 381 course, each student had the opportunity to present two projects. In the sample, there were 17 women, all of whom presented two projects, and 83 men, two of whom only presented one project. Of the women, 7 were seniors, 9 juniors, and 1 sophomore. Of the men, 2 were master level students, 27 seniors, 50 juniors and 4 sophomores. The master level students were seniors allowed to take graduate courses for credit.

Table 3 Distribution of Categories of Topics Chosen for Presentation in Fall 2004 MEEN 381

	vehicles	home & hobby	engines	energy	structures	materials	human body	intern experience	electronics
Women	26.47%	8.82%	5.88%	14.71%	2.94%	2.94%	17.65%	14.71%	5.88%
Men	30.12%	12.65%	10.24%	11.45%	6.02%	4.22%	3.01%	6.02%	16.27%

The categories that stand out for showing significant frequency differences are engines, materials, structures, human body, intern experience, and electronics. While home &

hobby did not show a significant difference between men and women, the aspects composing these project choices were different for men than for women. Specifically, the women's topics under home & hobby were dominated by children's toys and kitchen devices, while the men's projects were dominated by weapons, milling tools, other house mechanics and overall home integrative topics. In addition, it is interesting that most of the women who presented intern experiences tended to present a second intern-related project, while the men who presented intern experiences usually did not present a second intern-related project. Part of the explanation for women presenting more intern-related projects may be due to the fact that proportionally they were somewhat further along in their curricula than were the men. In other curricular aspects, the women were distributed similarly to the men in terms of previous courses taken.

Table 4 Distribution of Class Standing for Students in MEEN 381 in the Fall 2004

	Master	Senior	Junior	Sophomore
Women	0.00%	41.18%	52.94%	5.88%
Men	2.41%	32.53%	60.24%	4.82%

This course meets as a whole one day of the week, and on another day, it meets in six recitation sections in different locations. We also explored whether the presentation trends appeared to be different for women if their recitation section had more women enrolled. We saw no difference in the patterns of project choice for women in sections with more women enrolled from those with fewer women enrolled. (Section enrollments for women were 6%, 7%, 15%, 21%, 38%, and 42 %.)

The completion of an extensive outcomes assessment is required of all students just before the conclusion of the semester. It probes student reactions to the seminar course, as well as their reactions to the ME curriculum, the support courses, the effectiveness of the infrastructures of the university as well as the ME department, and solicits their comments and suggestions for improvement. In previous semesters, it had been noticed that the students reported that this course was significantly more effective at improving their oral communication skills than it was in helping them with writing. The faculty suspected that the practice of having all students in each recitation section provide written evaluations of each oral presentation was a great motivation. In the fall semester of 2004, the evaluation of the written reports was modified to include anonymous written feedback of each written report from two peer classmates. Not only did the assessment indicate that the students perceived the course was more effective in improving writing skills, the TA's noted that there was a noticeable improvement in the overall quality in the second submitted written reports over the ones submitted the first time. Co-author Weese will e-mail copies of the evaluation instruments for the written reports and oral presentations as well as the assessment instrument to anyone interested.

Retention and Graduation Data for Texas A&M University and the Dwight Look College of Engineering

The students enrolled in MEEN 381 in the fall semester 2004 were already admitted to upper division status and most were juniors and seniors. They continued in mechanical engineering in the spring unless they graduated in December.

Texas A&M University typically has a fall enrollment of 45,000 students. Of its ten colleges, the Dwight Look College of Engineering is one of the largest with approximately 10,000 students, of which about 7,500 are undergraduates and 2,500 are graduate students. It offers 14 programs in engineering and programs in computer science, all going to the doctoral level. It also offers a BS program in engineering technology with four options, and BS and MS programs in industrial distribution.

For the University as a whole, cohort retention rates of women exceed that of men for the first four years, with first year retention rates being approximately 90%. After four years, the cohort graduation rates of women average 45.9% and are more than double that of men, 22.9%. At six years, the graduation rate data are 80.7% for women and 70.6% for men.

From fall 1998 to fall 2003 for the College of Engineering, first year retention rates for First-Time-In-College (FTIC) students range from 66.3% to 70.3%. While retention rates for women are presently somewhat less, the rate of retention increase is higher for women than for men. A linear regression analysis of the data for 1998 to 2003 yields retention rate equations of:

$$\%R_{Men} = 67.6 + 0.65(\text{Year} - 1998),$$
$$\%R_{Women} = 62.4 + 1.29(\text{Year} - 1998).$$

These equations predict that the retention rate for women will match that for men in 2006 and that the retention rate for women will surpass the rate for men in 2007.

Cohort six-year graduation rates for FTIC students in the College of Engineering for the years 1996-2002, 1997-2003, and 1998-2004 reveal an average 50.1% for women and 48.6% for men.

As reported in [9], Texas A&M has taken decisive action to address diversity through vigorous recruitment of students and the addition of faculty from under-represented groups. Substantial changes have been made in the structure of the University, including hiring a Vice President for Diversity and Assessment. The College of Engineering vigorously supports this effort and takes leading action to improve the retention and graduation rates for women and under-represented groups. It has many active programs to stimulate interest in the study of engineering and enable students to study more effectively in more favorable living and study environments.

CONCLUSIONS

A significant aspect of looking at project choices for women in MEEN 381 is to note that, by this point in the curriculum, the vast majority of attrition from the major has already occurred for both men and women. Thus, we are clearly looking only at data for men and women who tend to persist in the major and we have no information from men or

women who left the major, which may be the place where more variances between men and women are found. We found it interesting that prior socialization at home seemed to be behind some of the interest in mechanical topics for home & hobby. We did not expect to see fewer women choose material topics than men, because the national data for engineering shows women are more represented in material engineering than mechanical engineering. The fact that more women than men seemed to be interested in the mechanics of the human body seems to align well with numerous studies about young children, which show that girls have more interest in living things (dolls, stuffed animals, pets) than boys who have stronger interests in devices (balls, blocks, computers). This also aligns with Texas A&M enrollment data which indicate a greater representation of women in biological sciences, medicine, and Biomedical Engineering, than found in Mechanical Engineering. Similar experiences and trends may explain why the men appeared to be more interested in engines, as objects, than the women were. While the women presented intern experiences much more often than men, we do not have appropriate information to conclude whether they have had more and/or better internship experiences, or if they are just more reflective about their experiences than the men. It is clear that no significant difference appeared where the women participated in internships. Finally, the large number of men's presentations in electrical or electronic areas were dominated by computer systems, with a fair number focused on computer games. Much like the comment on home & hobby, and aligning with studies about young boys' interests in devices, the greater number of men choosing electronic projects was not surprising.

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