

COLLEGE WOMEN IN ENGINEERING: COMPARISON OF THEIR BACKGROUNDS, ABILITIES, VALUES AND GOALS WITH SCIENCE AND HUMANITIES MAJORS

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Introduction

This study explores why some capable women enter engineering fields while others do not. Special attention is given to exploring the differences among women selecting engineering vs. science majors, as well as women science majors selecting to study at an engineering vs. a liberal arts college environment.

The purpose of this study is threefold: a) to quantify the characteristics of freshmen women engineers at a predominantly engineering institution, b) to contrast the characteristics of freshmen women engineering majors with those of humanities and science majors to better understand what motivates some young women to select engineering majors, and c) based on the results, to suggest how more young women could be attracted to engineering.

Method

Samples

Four groups of capable women students were identified based on their intended major:

- 1) engineering N = 80
- 2) humanities N = 156
- 3) science majors at engineering college (EC) N = 37
- 4) science majors at liberal arts college (LC) N = 113

To rule out lack of ability as a factor in selecting engineering as a major, only capable freshmen women were included in the study. The women were viewed as capable/well-educated because they had been selected for admission by two very selective colleges. One of the two institutions offered predominantly engineering curricula (EC), the other liberal arts programs (LC). Because the engineering institution enrolled a higher percentage of international students with associated lower SAT Verbal and other scores which would influence further analyses, only declared U.S. citizens were included in the samples.

Variables

All students completed the 1992 Student Information Form (Astin, 1992) administered during college freshmen orientation, resulting in a return rate of 99%. The Higher Education Research Institute at the University of California at Los Angeles separately tabulated the responses of freshmen students from both colleges. These student responses are routinely recorded onto data diskettes and made available to the colleges for institutional analysis. This investigator was given access to the data to conduct the current study.

Only three subsets of the overall data base were used because it was judged that this data had the potential to uncover differences among the groups of students. The following segments of the overall data base were used:

- a) student self-ratings on specific abilities,
- b) student ratings on the importance of certain goals and values,
- c) parental background information, student political orientation, SAT and ACT scores, and number of years certain subjects were taken in high school.

Statistical Analysis

A total of 48 variables were selected for statistical analysis. Null hypotheses were that women engineering, science, and humanities students would not differ on any of the variables. A one-way analysis of variance (ANOVA) among the groups was performed for each of the 48 variables separately. When a significant F ratio was observed on a variable, the statistically conservative Scheffe post-hoc comparison test was applied to identify specific statistical differences between the groups.

Due to the large number of variables analyzed, it is understood that some differences are likely to be significant due to chance alone. However, the value of these analyses is in the highlighting of highly significant variables which can be assumed to reflect important differences among the groups. Also, the large number of variables is helpful in the identification of possible interactions among these variables. The identification of the significant variables and their interaction (or lack thereof) with each other are *both important* to understanding the career choice process among pre-college women engineers.

Results

Characteristics of Freshmen Women Engineers

Abilities Respondents rated their own abilities on a scale of 1 to 5 with a rating of 5 indicating that the respondent thinks that her own abilities are in the top 10% of her peer group. Engineering students rated highest their drive to achieve (4.2), academic ability (4.18), mathematical ability (4.09), ability to cooperate (3.98), ability to understand others (3.84), and physical health (3.73). Rated lowest were social self-confidence (3.23), popularity (3.2), public speaking (3.06), and artistic ability (2.96).

Goals and Values Goals and values were rated on a scale of 1 to 4, with 4

being viewed as an essential component of one's life, and 3 being very important. Of most importance to engineering majors was becoming an authority in one's own field (2.96), being successful in own business (2.91), being well off financially (2.87), obtaining recognition from colleagues (2.83), and helping others in difficulty (2.81).

Maternal Education The highest educational level attained by the mothers of women engineers were as follows: 16% held a graduate school degree or attended some graduate school, 26% held a college degree, 20% attended some college, 11% attended postsecondary school other than college, 25% graduated from high school, 1% attended some high school.

Paternal Education The highest educational level attained by the fathers of women engineers were as follows: 19% held a graduate degree or attended some graduate school, 36% held a college degree, 16% attended some college, 9% attended a postsecondary institution other than college, 13% held a high school degree, 3% grammar school or less.

Parental Income In estimating pre-tax parental income levels, 8% of women engineers indicated that their parents earned \$24,999 or less a year, 16% between \$25,000 and \$39,999, 32% between \$40,000 and \$59,000, 32% between \$60,000 and \$99,999 and 12% between \$100,000 and \$199,999.

Academic Background Women engineers achieved a mean SAT Verbal score of 523, a mean SAT Math Score of 621, and a mean ACT score of 29. In high school, women engineers took about four years of math, two years of physical science, one year of biological science, and one-half of a year of computer science.

Contrasting the Characteristics of Women Engineering Majors with Those of Science and Humanities Majors

Similarities Among Groups No statistical differences were found on 27 of the 48 variables under analysis. Most importantly in terms of contributing to overall knowledge of the career development of women engineers, the groups of women were similar with respect to:

- a) self-ratings of academic ability and social and intellectual self-confidence,
- b) self-ratings of the drive to achieve
- c) self-ratings of leadership abilities and the ability to cooperate
- d) value placed on the importance of raising a family
- e) political orientation
- f) marital stability of the parents
- g) level of mother's education.

Differences Among the Groups Statistically significant differences for post hoc group differences are summarized in Table 1. *In order to read Table 1, follow the procedure given for the first variable under "Abilities": locate the first ability of "competitiveness" and find the corresponding ".05³". This entry means that significant statistical difference was observed at the .05 level between the two groups compared and that women science (LC) majors rated themselves higher on the variable of competitiveness than women engineering majors.*

Differences and Interactions of Statistically Significant Differences Pairwise post hoc group comparisons showed statistical differences among the groups on 21 of the 48 variables. Among the more noteworthy differences are:

- a) women engineers rated themselves highest on mathematical ability but did not obtain the highest SAT Math scores
- b) science (EC) majors obtained the highest SAT Math scores but not the highest self-ratings on mathematical ability
- c) women engineers reported the lowest *paternal* educational level
- d) science (EC) majors reported the lowest parental income level
- e) women engineers rated highest the importance of being very well off financially
- f) women engineers rated highest the importance of being successful in one's own business
- g) women engineers have the lowest SAT Verbal scores

Differences among the Engineering College and Liberal Arts College Groups

- a) The liberal arts college students placed greater value on the importance of political and social activist ideas and work than did engineering college majors. (These differences are obvious on goal and value items such as "influencing political structure, influencing social values, developing a meaningful philosophy of life, participating in community action programs, promoting racial understanding and becoming a community leader.")
- b) There were no differences found on political orientation or the value of keeping up-to-date with political affairs.
- c) The liberal arts college students reported higher parental income levels.

Differences between Science (LC) and Science (EC) samples

- a) Science (EC) rated higher the importance of being financially well off
- b) Science (EC) reported fewer parents alive and living together and lower parental income
- c) Science (LAC) rated higher their public speaking ability
- d) Science (LAC) placed greater value on the importance of political and social activist ideas.

Table 1 Post Hoc Comparison of ANOVA Results^a

Variables	Eng ¹ + Sc(EC) ²	Eng ¹ + Sc(LC) ³	Eng ¹ + Hum ⁴	Sc(EC) ² + Sc(LC) ³	Sc(EC) ² + Hum ⁴	
<u>Abilities</u>						
Competitiveness		.05 ³				
Mathematical Ability	.05 ¹	.05 ¹	.001 ¹		.001 ²	.001 ⁴
Popularity			.05 ⁴		.05 ⁴	
Public Speaking Ability				.05 ³	.05 ⁴	
Reading Speed/Comprehension			.01 ⁴			
Writing Ability			.01 ⁴		.001 ⁴	.05 ⁴
<u>Goals & Values</u>						
Influence Political Structure			.01 ⁴		.001 ⁴	.01 ⁴
Influence Social Values			.01 ⁴	.05 ³	.001 ⁴	
Be Very Well Off Financially		.05 ¹	.05 ¹	.01 ²	.01 ²	
Help Others in Difficulty		.01 ³	.05 ⁴	.01 ³	.05 ⁴	
Make Theoretical Contribution to Science			.001 ¹		.001 ²	.001 ³
Write Original Works			.05 ⁴		.05 ⁴	.01 ⁴
Be Successful in Own Business	.01 ¹	.01 ¹	.001 ¹			
Be Involved in Environmental Cleanup		.01 ³	.05 ⁴			
Develop Meaningful Philosophy of Life		.01 ³	.001 ⁴	.01 ³	.001 ⁴	
Participate in Community Action Program		.05 ³	.01 ⁴	.05 ³	.01 ⁴	
Promote Racial Understanding		.05 ³	.001 ⁴	.05 ³	.001 ⁴	
Become a Community Leader		.01 ³	.05 ⁴	.05 ³		
<u>Other</u>						
Parental Marital Status		.05 ³		.01 ³		
Parental Income			.05 ⁴	.05 ³	.01 ⁴	
Father's Educational Level	.05 ²	.01 ³	.001 ⁴		.05 ⁴	
Verbal SAT	.01 ²	.01 ³	.001 ⁴		.05 ⁴	.05 ⁴
Math SAT			.01 ¹		.001 ²	.01 ³
ACT				.05 ²	.01 ²	
Years of Mathematical Study			.05 ¹			
Years of Biological Sciences	.001 ²	.001 ³			.05 ²	.001 ³

^aValue of p is less than value given [p < value].

Legend: 1 = Engineering; 2 = Science, Engineering Col.; 3 = Science, Liberal Arts Col.; 4 = Humanities



WOMEN IN ENGINEERING CONFERENCE: EFFECTING THE CLIMATE

1994 WEPAN National Conference

Implications for Increasing the Number of Women Engineers

Recruitment In order to boost the applicant pool of women engineers, recruiters would do well to focus on high school women who:

- a) are self-confident about their mathematical ability and
- b) value the achievement of entrepreneurial and financial goals.

Professional Marketing Many capable women science and liberal arts majors who would be accepted into engineering programs or other programs in a predominantly engineering college do not apply for admission.

It is likely that many of these women do not apply to engineering schools because they do not perceive engineers as being involved in addressing societal concerns. This perception is most likely based on a lack of awareness and about the many kinds of work that engineers do. The wide-spread usefulness and challenge of engineering work has not been translated to successful TV shows and other forms of mass communication as it has been for the legal, medical and police professions.

Therefore, engineering school personnel interested in attracting a larger pool of women engineering students need to address the topic of attracting capable women who would make good engineers, yet who also value being involved with common societal problems.

Addressing the topic might be accomplished by continuously advertising the relevance of engineering work to common communication, social, environmental, medical, and other people-related problems. By representing the engineering professions as clear, direct, interesting avenues for helping others, more capable young women would be attracted to study at engineering colleges and become engineering majors. Engineering recruiters need cost-efficient, effective ways of delivering this message.

Limitations of Study Replication of this study with larger, broader samples of women would counter possible idiosyncratic characteristics of the colleges involved in this study. For example, the value placed on social involvement by the liberal arts college samples is most likely influenced by the religious history of the college and its accompanying emphasis of doing good works. Also, because the engineering college supplies 72% of its student population with financial aid, while the liberal arts college provides for only 50%, it is possible that the engineering college is perceived as particularly receptive to financially needy applicants and therefore draws applicants from different socioeconomic strata than the liberal arts college. If this were in fact a major source of difference between the two campuses, then many differences between engineering majors and humanities majors could be explained in terms of differential economic backgrounds and needs.