

## **AC 2009-611: CAREER MOTIVATIONS OF FRESHMAN ENGINEERING AND NON-ENGINEERING STUDENTS: A GENDER STUDY**

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# Career Motivations of Freshman Engineering and Non-Engineering Students: A Gender Study

**Keywords:** career motivation, outcome expectations, gender differences

## Abstract

A social cognitive career theory framework and Vroom's valence model are used to examine the importance that female freshman engineering students (n=87) place on various career-related outcomes, compared with other female freshmen (n=2236) and with male engineering students (n=484). The female engineering students were significantly different from both groups on several measures. This study finds that, in terms of certain career-related outcome valences, women students who choose engineering are not representative of women students in general, nor are they representative of engineering students in general. On three measures, they do not even fall between both comparison groups.

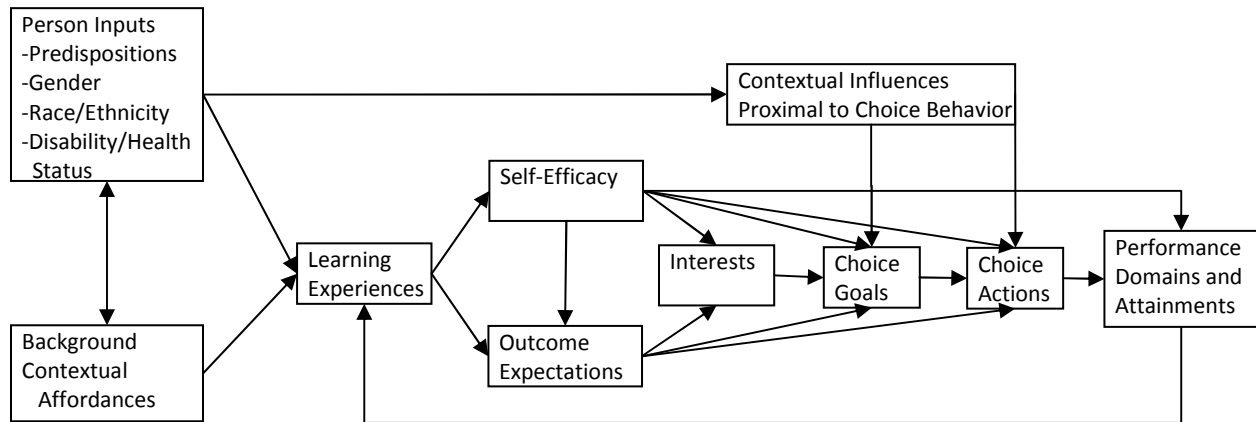
## Introduction

Engineering professions have been far less successful than other professions at attracting female students. While the overall percentage of Bachelor degrees conferred to women in the 2005-2006 academic year was 57%, in engineering only 19% of the graduates were women<sup>1</sup>. This study attempts to shed light on this phenomenon by addressing the following questions: Are the career motivations of females who choose engineering representative of the career motivations of female freshmen in general? Furthermore, how do the career motivations of these female engineering students compare to those of male engineering students? This is achieved by examining the importance, or valence (a term used in psychology to denote the intrinsic attractiveness of an object, situation, or event), that students associate with career-related outcomes.

Two major theories are relevant to the current study. The Social Cognitive Career<sup>2</sup> theory gives a broad picture of many variables associated with the development of academic interest, choice, and performance over time. However, in order to examine the relationship between outcome expectations and occupational preference in more depth, the detail provided by Vroom's Expectancy Theory<sup>3</sup>, specifically the valence model, is useful.

Social Cognitive Career Theory<sup>2</sup> can be used as a lens through which to examine which types of outcome expectations women and men have about an engineering career. According to Bandura's social cognitive theory<sup>4</sup>, outcome expectations are the anticipated consequences of a course of action and can be physical, social, or self-evaluative. For example, a student might expect that the outcome of earning an engineering degree will be making money (physical), becoming well-known (social), or developing new knowledge (self-reflective). Lent, Brown, and Hackett used Bandura's theory to explain the development of career interests, choices, and performance. According to their Social Cognitive Career Choice Model, shown in Figure 1, person inputs, such as gender, affect outcome expectations through learning experiences. Outcome expectations in turn have both direct and indirect effects on choice goals. In this context, a choice goal is the occupation that a person chooses to pursue, which leads to choice

actions, such as enrolling in an appropriate program for the chosen profession. Self-efficacy also plays a large role in the development of outcome expectations, interests, choice goals, choice actions, and performance.



**Figure 1: Model of the career/academic choice process (R.W. Lent, S.D. Brown, and G. Hackett, 1994).**

A large body of research has experimentally examined the various links and propositions put forth by the model. Fouad and Smith showed that the link between outcome expectations and intentions (called choice goals in the career model) is strong in math and science for middle school students. They also found that the male students had higher outcome expectations in these subject areas<sup>5</sup>. Fouad, Smith and Zao confirmed the outcome expectation-goal link in college students across four subject domains, although it was noted that this link was less strong for math/science<sup>6</sup>. Lent et al. found a significant link between outcome expectations and Major choice goals for predominately White institutions, but not at historically Black universities. The link between outcome expectations and career goals is also evident in the expectancy-value model<sup>7</sup>.

Vroom's valence model weighs the link between an individual's preferred occupation and the value (valence) he/she places on certain outcomes. The valence,  $V$ , or preference, for occupation  $j$  is equal to the sum over all outcomes of the product of the valence for the  $k^{\text{th}}$  outcome and the perceived instrumentality,  $I$ , of occupation  $j$  in affording the  $k^{\text{th}}$  outcome.

$$V_j = \sum_{k=1} (I_{jk} V_k)$$

In other words, for an individual to value a certain occupation, they must perceive that the occupation will afford them the outcomes they desire. Vroom also recognizes that the occupations that individuals prefer are not necessarily the occupations they eventually choose. His expectancy model is similar in form to the valence model and posits that actual actions taken are moderated by the individual's perceived probability of success in executing the necessary actions. Positive support of the valence model has been reported by Vroom<sup>8</sup>; Sheard<sup>9</sup>; Vroom and Deci<sup>10</sup>; Mitchell and Knudsen<sup>11</sup>; and Lawler III, Kuleck, Rhode, & Sorensen<sup>12</sup>. A summary of these results is presented by Mitchell & Beach<sup>13</sup>.

For the purposes of our study, the social cognitive career theory provides a broad explanatory foundation, with factors that influence outcome expectations and are influenced by outcome expectations. The valence model provides a specific quantifiable relationship between outcome expectations and career goals.

In this study, students have been asked which profession they aspire to and how important various outcomes are to their future career satisfaction. Under Vroom's preference model, we can assume that the students who choose engineering believe that it will afford the outcomes which they value the most. For instance, if students value helping other people, they will choose a career that they expect will enable them to help people. The goal of this study is to answer the following questions in hopes of better understanding the women that do choose engineering and why many women do not.

1. Do women who choose engineering place the same importance on career-related outcomes as other women?
2. Do women who choose engineering place the same importance on career-related outcomes as other engineers?
3. Does the importance that women engineers place on career-related outcomes fall between that of other women and that of male engineers?

## **Method**

### *Subjects and Procedure*

A nationally-representative sample of college English students was surveyed in the fall of 2007 about their career interests, related attitudes, and experiences in science and engineering. Since introductory college English students were surveyed, the project is able to examine the motivations and experiences of a spectrum of students, ranging from those who wanted to become engineers to those who had different career plans. Students at 34 randomly selected colleges/universities across the United States completed 6860 surveys (4801 freshmen). Overall, 51% of the sample was female. This study compares the importance that freshman female engineers (n=87) placed on various career-related outcomes with corresponding results for freshman female non-engineers (n=2236), and for freshman male engineers (n=486).

### *Instrument*

The data used in this study was drawn from the PRiSE (Persistence Research in Science & Engineering) Project, which focuses on identifying high school factors that influence the persistence of females in science, technology, engineering and mathematics (STEM) disciplines. Funded by the National Science Foundation, PRiSE is a large-scale study that surveyed a nationally-representative sample of college English students about their interests and experiences in science and engineering. The development of the PRiSE survey was guided by three major components: i) an extensive literature review to extract factors that might influence persistence in STEM fields, ii) open-ended, free-response questionnaire responses from 259 high school science teachers and 153 scientists/engineers on what factors, especially in high school, influence persistence in STEM (over 100 pages of analyzed text), and iii) an extraction of items from a previous national study (Factors Influencing College Science Success – FICSS – see

www.ficss.org for more information) that showed significant gender differences. Reliability for the survey was established through a test-retest study and translational validity was established through focus groups with science education experts (researchers and experienced practitioners) and students.

Students were asked to select, from a list of professions, what they wanted to be in middle school, high school, and college. The profession they indicated for the college stage (that is, their current career aspiration) was used to identify their career choice goal. The students were also asked to rate 15 factors “in terms of their importance for your future career satisfaction” on a scale of 1 to 6, with 6 indicating “very important.” Examples include: making money, becoming well known, and helping other people. (See complete list in Table 1.)

### Data Analysis

To answer the first research question, the women who chose engineering were compared with the women who chose another occupation on each factor. Missing values were excluded on a pair-by-pair basis. Because of the difference in sample size, Welch’s t-test was used for statistical analysis, which does not assume equal variances. The same process was used to compare women and men within engineering.

### Results

For reference, outcome valences are compared across gender and male engineers are compared to male non-engineers. Only 3.7% of the women indicated that they wanted to be an engineer, compared to 22.2% of the men. The only outcome valences that were not different between genders were making their own decisions, making money, developing new knowledge and skills, and having lots of time for themselves/friends (Table 1). Each of these outcomes was rated moderately high, regardless of gender.

**Table 1: Outcome Valences by Gender**

Outcome	Female (n=2395)		Male (n=2293)		
	M	SD	M	SD	
Having job security	<b>5.12</b>	1.13	5.04	1.11	*
Having lots of job opportunities	<b>4.88</b>	1.16	4.73	1.17	***
Making use of my talents/abilities	<b>5.24</b>	0.92	5.16	0.96	**
Having an exciting job	<b>5.03</b>	1.07	4.96	1.11	*
Making my own decisions	4.88	1.07	4.85	1.06	
Helping other people	<b>5.16</b>	1.12	4.50	1.29	***
Making money	4.74	1.19	4.81	1.21	
Having lots of family time	<b>5.09</b>	1.08	4.79	1.17	***
Developing new knowledge and skills	4.57	1.35	4.57	1.25	
Having lots of time for myself/friends	4.54	1.18	4.49	1.16	
Inventing new things	2.35	1.44	<b>3.17</b>	1.55	***
Working with people	4.59	1.39	<b>4.01</b>	1.44	***
Having others work under my supervision	3.03	1.46	<b>3.34</b>	1.47	***
Having an easy job	2.97	1.34	<b>3.14</b>	1.44	***
Becoming well known	2.81	1.50	<b>3.19</b>	1.54	***

\* p<0.05, \*\* p<0.01, \*\*\* p<0.001

The female engineers rated the importance of seven outcomes significantly differently, compared with female non-engineers. Of these, five were also significantly different from the male engineers. No significant differences were noted among the groups in the importance of developing new knowledge, having an easy job, having an exciting job, supervising, making money, making their own decisions, job security, or using talent. These results are summarized in Table 2 and Figure 2.

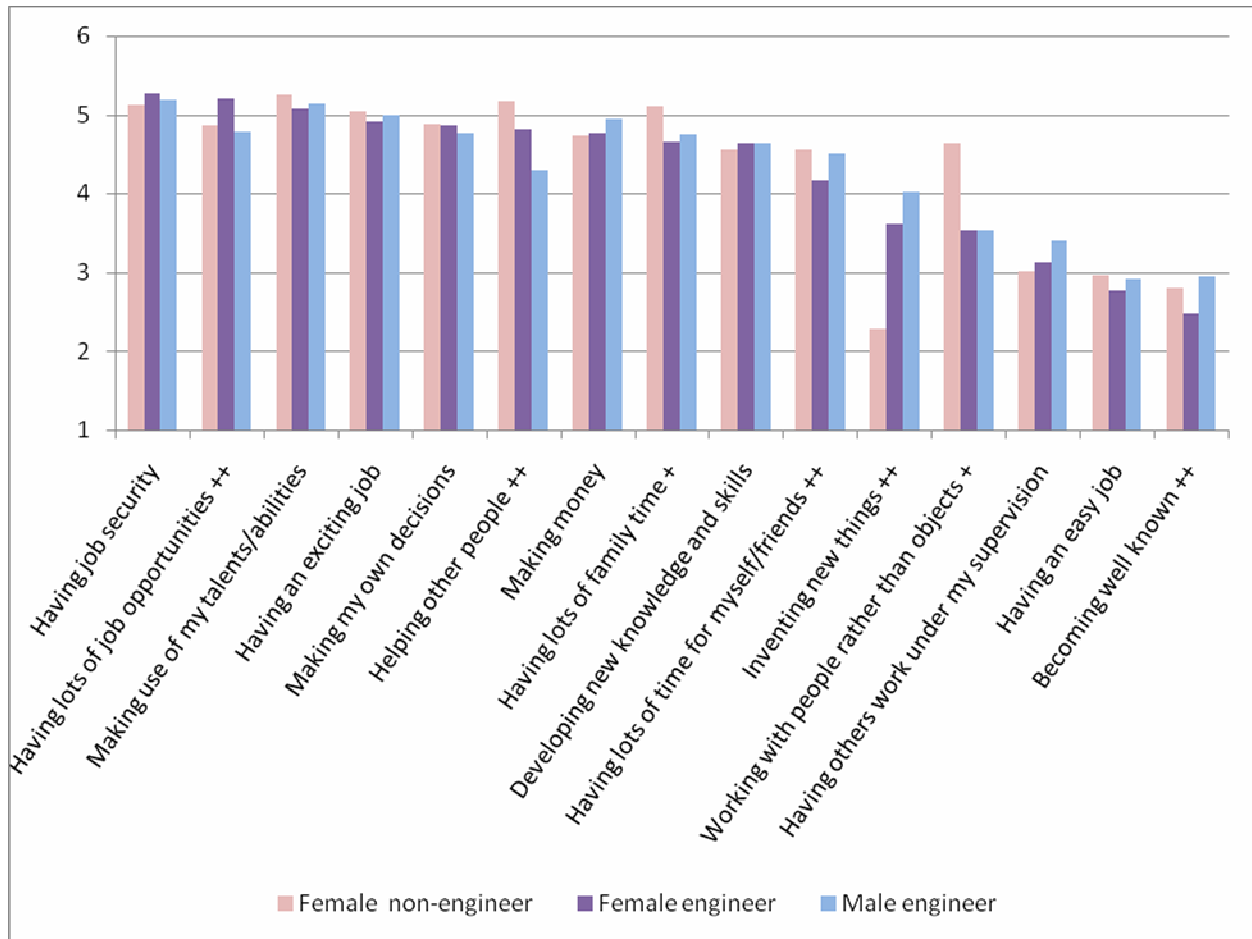
**Table 2: Outcome Valences of Female Engineers compared with female non-engineers and male engineers**

Outcome	Female non-engineer (n=2236)		Female engineer (n=87)		Male engineer (n=484)	
	M	SD	M	SD	M	SD
Having job security	5.12	1.13	5.27	0.78	5.19	0.98
Having lots of job opportunities	4.87 **	1.16	<b>5.20</b>	0.90	4.78 ***	1.12
Making use of my talents/abilities	5.26	0.90	5.08	0.93	5.14	0.93
Having an exciting job	5.05	1.05	4.91	1.14	4.99	1.00
Making my own decisions	4.88	1.08	4.87	0.90	4.76	1.03
Helping other people	<b>5.17</b> **	1.12	4.82	1.14	4.30 ***	1.27
Making money	4.73	1.19	4.76	1.08	4.94	1.02
Having lots of family time	<b>5.10</b> ***	1.07	4.66	1.11	4.75	1.09
Developing new knowledge and skills	4.56	1.35	4.64	1.33	4.64	1.17
Having lots of time for myself/friends	<b>4.56</b> **	1.18	4.17	1.06	<b>4.50</b> *	1.06
Inventing new things	2.29 ***	1.41	3.61	1.39	<b>4.02</b> *	1.41
Working with people rather than objects	<b>4.63</b> ***	1.37	3.54	1.19	3.54	1.37
Having others work under my supervision	3.01	1.47	3.13	1.24	3.40	1.38
Having an easy job	2.96	1.33	2.77	1.18	2.91	1.28
Becoming well known	<b>2.81</b> *	1.50	2.48	1.15	<b>2.95</b> **	1.48

\* indicates a significant difference from the Female Engineers\* p<0.05, \*\* p<0.01, \*\*\* p<0.001

Women who chose engineering rated seven of fifteen outcomes differently from other women. They placed significantly less importance on having time for family (p<0.001), having time for self/friends (p<0.01), working with people rather than objects (p<0.001), helping others (p<0.01), and becoming well-known (p<0.05). They also reported that inventing new things (p<0.001) and working in an area with lots of job opportunities (p<0.01) were more important to their career satisfaction.

Compared to men who indicated engineering as their preferred profession, women who chose engineering rated helping others (p<0.001) and having job opportunities (p<0.001) as more important. They also rated having time for self (p<0.05), inventing new things (p<0.05), and becoming well-known (p<0.01) as less important.



**Figure 2: Importance rating of outcomes (+the Female Engineers are significantly different from the female non-engineers, ++the female engineers are significantly different from both the female non-engineers and the male engineers).**

## Discussion

The differences in outcome valences across gender that emerged in the present study are at variance with results reported by Brooks and Betz<sup>14</sup> who found that men and women were not significantly different on outcome valences except for “allows leisure activities.” It is possible that the large sample size of this study exposed gender differences that are small but significant. Differences in work values have also been found by Beutell and Brenner<sup>15</sup>.

*Do women who choose engineering place the same importance on career-related outcomes as other women?*

The results of this study show that women who want to be engineers have a somewhat different set of career-related values than do other women. They found it much more important to invent new things, but slightly less important to become well known. They also reported that working with people was much less important to them than it was to other women. The few women being attracted to engineering are clearly not representative of women in general. It seems that women who care a lot about working with people turn to other fields. This is a little surprising because

the engineers of today often work in teams, as evidenced by ABET criterion 3d<sup>16</sup> and outreach programs such as JETS (Junior Engineering Technical Society)<sup>17</sup>. This message may not be getting through. Additionally, there may be a spirit of sacrifice, or simply an unusually strong work and career focus, among these women. They found it much less important to have time for family, friends, and self, but more important to have job opportunities. These results imply that the social and cultural messages women may be receiving characterize engineering professions as requiring the de-prioritization of other personal and social goals, thus attracting only the women who do not have such goals or are willing to abandon them. This poses a particular problem when trying to recruit more women into engineering fields because, as in this study, females have been found to be more motivated by careers that afford interpersonal goals<sup>18-20</sup> and that will allow them to maintain multiple roles<sup>21-23</sup>, including that of family caretaker. More appropriate characterizations of engineering are the desire to invent new things and the availability of jobs, which were values held more strongly by the females who wanted to be engineers. These results highlight the possibility of a greater desire for independence, both mental (e.g. freedom to develop ideas into new products) and material (e.g. freedom afforded by not relying on someone else for financial support), on the part of the females who wanted to be engineers, as compared with the other females.

*Do women who choose engineering place the same importance on career-related outcomes as male engineers?*

If the women who are attracted to engineering are not like other women, then perhaps they are the outliers who have values similar to men who choose engineering. While it appears they are more similar to engineering men, there are still some very significant differences, the largest difference being the greater importance they put on helping others (Table 3). Still, on this measure they lie between engineering males and non-engineering females. A report by Gibbons found that women are most likely to choose certain fields within engineering (biological and agricultural, biomedical, chemical, environmental, and industrial/manufacturing engineering)<sup>24</sup>. It is plausible that women choose these disciplines because they afford opportunities to help people and the environment. Although having time for self/friends was not significantly different between the genders in general (Table 1), the female engineers rated this significantly lower than the male engineers. This further cements the argument that women who choose engineering are more likely to think that job requirements must take precedence over personal time.

*Does the importance that women engineers place on career-related outcomes fall between that of other women and that of male engineers?*

One might expect that if women hold a certain set of values and engineers hold another set, the values that women who are engineers place on outcomes should fall somewhere between the two sets. However, as shown in Figure 2, on three different factors, the engineering women were significantly more extreme than both comparison groups. These women were more concerned about having job opportunities and less concerned about having time for themselves or friends and becoming well known. A relatively low rating on becoming well-known and a high rating on inventing new things suggests these women are intrinsically motivated. It may be that only the women most dedicated to the spirit of invention are willing to endure the so-called null academic environment<sup>23, 26</sup> characteristic of most technical fields. Freeman's null environment



hypothesis is that “an academic environment that neither encourages nor discourages students of either sex in inherently discriminatory against women because it fails to take into account the differentiating external environments from which women and men students come.”

## Implications

These findings suggest that the social perceptions regarding engineering disciplines do not present an appealing choice to most women. For the other 96% of women to become interested in engineering as a possible career path, they must perceive the engineering environment to be one that will afford the outcomes that they value. Women who valued having family time were less likely to choose engineering, probably because they see engineering as incompatible with family responsibilities. Nauta, *et al.*<sup>27</sup> suggest that increased access to role models who successfully manage family and work responsibilities can help overcome this problem. One way to accomplish this is through informal interactions with instructors where students have the opportunity to see that role conflict can be overcome. In addition, STEM teachers at earlier levels need to begin countering stereotypes that engineering is a one-dimensional field that requires giving up social interaction and other desires. At the tertiary level, engineering organizations can be restructured to actually support the dual-role that many women play by offering job-sharing, part-time work, on-site childcare, and other family-friendly resources<sup>27, 28</sup>.

## Conclusion

The female engineering students were similar to the male engineering students in their lower motivation for working with people and having lots of family time. The female engineers fell between the female non-engineers and male engineers on helping other people and inventing new things, although they were significantly different from both groups. Most interestingly, the female engineers rated having lots of time for themselves/friends and becoming well known significantly lower than *both* comparison groups and having lots of job opportunities significantly higher than both groups. In summary, engineering is attracting an outlying subset of the female population with regards to certain motivations, and these females are somewhat more extreme in certain career motivations than even the average male engineer. It may be necessary for women to have a greater adherence to the values ascribed to engineering professions in order to overcome the social barriers and choose engineering. These results imply that the social and cultural messages women may be receiving characterize engineering professions as requiring the de-prioritization of other personal and social goals, thus attracting only the women who are willing to sacrifice such goals.

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