GRADUATE CAREER CHANGE WOMEN ENGINEERS
versus
TRADITIONAL ENGINEERS

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Introduction

"An engineer is not an average person....Numerous studies show that compared with the population as a whole, the American engineer is less well-read, a better family member, more conservative politically, more oriented to the use of numbers rather than general philosophical positions in making a decision, and more goal oriented," so concludes Billy Vaughn Koen. [1] In addition, the "average" American engineer is a male. In fact, according to a 1986 study, the latest by the National Science Foundation, 96% of the U.S. employed engineers are men. [2]

In 1982, a Graduate Career Change Program in Industrial Engineering was established at Arizona State University (ASU). Initially this program was partially funded by the National Science Foundation (NSF). Under the NSF guidelines, this program sought women who had held a Bachelor's degree for at least two years and were unemployed in a technical area or underemployed in terms of potential. Successful completion of certain prerequisite courses and a 30 hour program of study culminates in a Master of Science in Engineering degree. Later the program also included men interested in career change. However, most of the program participants have been women, and until very recently none of the participants had majored in engineering for their undergraduate degree. Some of the women had math or science backgrounds, some a liberal arts or education background. Whatever the first career, the women who entered the program now wanted to pursue a graduate degree in engineering.

It is very difficult to change careers as these women did. In most cases, the career change student has several prerequisite courses to complete before they can even be accepted into the Graduate College of ASU. In some cases, the career change woman has to start with intermediate algebra in order to complete the required three semester Calculus course sequence. The prospect of trying to go back to school and to enter a very technical, male-dominated field is very intimidating to most women. Insecurity and self-doubt are prevalent. Can she compete in the classroom after having been out for many years? Can she compete against younger students who have a stronger technical background?
Can she make it in the field after the degree? In addition, most often, the career change student must give up a full-time, paying job to go back to school. Even though her job may not be high paying, rewarding, or challenging, it is usually a very secure job. A few women seek to reenter the work force after staying at home for several years to raise a family. Some women take out loans as an investment in their future in order to finance going back to school.

There are many women with a Bachelor's degree who are unhappy with their careers and who desire career change. In the Phoenix Valley alone, this author has spoken to well over 1000 such women. Yet only a few have actually quit their job and gone back to school for a degree to help effect career change. Who are the women who have chosen engineering for a career change and who have survived? How do they compare to the "average American engineer?"

**Survey Demographics**

In the summer of 1990, a survey was taken of some of the ASU Graduate Career Change Program participants. The "first class" of those surveyed is comprised of women who entered the program in 1982 and 1983. The 25 who returned the survey were 100% of the participants from that time with addresses presently known to the program director, the author of this paper. It is assumed that the population of women whose addresses are not known does not differ from those whose addresses are known. Of the 25, 24 received their Master's degree in engineering and the 25th completed the program except for her Engineering Report (thesis substitute). She is employed as an engineer and her incomplete report and lack of actual degree does not seem to have hurt her successful career change. The "last class" is comprised of women students who were currently in the program at the time of the survey or who had graduated in December 1989 or May 1990. The population size was 10 and all completed the survey. The basic demographics of these two classes is shown in Table 1.

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>CAREER CHANGE CLASS DEMOGRAPHICS</th>
<th>1990 SURVEY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>FIRST CLASS(ES)</td>
<td>LAST CLASS</td>
</tr>
<tr>
<td></td>
<td>AVERAGE</td>
<td>AVERAGE</td>
</tr>
<tr>
<td>Age when entered program</td>
<td>31.4</td>
<td>33.3</td>
</tr>
<tr>
<td>Held Master's degree</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>Years of schooling by father</td>
<td>13.92</td>
<td>15.00</td>
</tr>
<tr>
<td>Years of schooling by mother</td>
<td>14.38</td>
<td>14.80</td>
</tr>
<tr>
<td>Number of children in family</td>
<td>3.72</td>
<td>3.30</td>
</tr>
<tr>
<td>Birth order</td>
<td>2.12</td>
<td>2.10</td>
</tr>
<tr>
<td>Age first heard of engineering</td>
<td>14.16</td>
<td>13.90</td>
</tr>
<tr>
<td>Age first considered engineering</td>
<td>26.88</td>
<td>27.00</td>
</tr>
<tr>
<td>Years considered career change</td>
<td>2.05</td>
<td>2.40</td>
</tr>
</tbody>
</table>

Women in Engineering Conference: A National Initiative
1991 WEPAN National Conference
The demographics on these two groups are quite similar. The average age of the career change participant was about two years older for the last class. This difference can be partially accounted for by two older career change women who affected the average in the smaller sample size (10) of the last class.

The career change woman is entering the graduate engineering program at approximately the same age as the average age of the woman engineer in the work force. The 1986 NSF study determined that the average age of a female engineer was 31.7 years and that the average age of a male engineer was 44.1 years. [2] In 1988, the Society of Women Engineers (SWE) conducted a pilot survey of over 400 engineers, approximately half women. [3] In this survey, the average age of the men was 45.2 and the average age of the women was 32.0.

Industrial Engineering, the most people-oriented of the major engineering disciplines, attracts a few more women engineers (5%) than the average (4%). Of the Industrial Engineers working in 1986, the men were on the average approximately 44.3 years and the women 30.0 years of age. [2] The lower average age for female industrial engineers is a reflection of the increased percentage of female graduates in Industrial Engineering in recent years. For example, in 1990, 28.0% of B.S. graduates in Industrial Engineering were women, compared with only 15.4% of all engineering graduates being women. [4]

A drastic difference in the two classes is noted in the number who held a Master's degree upon entering the Graduate Career Change Program. A larger percentage of the first class had been in education than in the last class. Most of the participants with the education background had earned a Master's degree in education since post baccalaureate work was required as a part of their job.

The number of years of schooling by the mother relative to the number of years of schooling by the father is of interest. In the first class, the mothers actually have a little more schooling than the fathers on the average. The average number of years of schooling by each parent of the last class is also very close. Of significance is the fact that, on the average, the mothers of the career change participants have at least two years of schooling beyond high school. Dr. Paula Rayman has observed that the education level of the mother is a significant factor in influencing women's attachment to science at both the undergraduate student level and for women in their later careers. [5]

On the average the career change participant in both classes is the middle child in a family with three children. These statistics came as somewhat of a surprise to the program director who had the impression that many of the career change women, especially in the first class, were the oldest in their family or an only child.
The average age when the women first heard about engineering was around age 14 for both classes. None of these women chose engineering as a course of study when they first entered college. This late age, to even be aware that a career in engineering exists, emphasizes the need for engineering awareness to be taught in the grades and junior high classes at the latest. On the average these women did not consider engineering as a career until nearly 13 years later. Additionally once they considered an actual career change for themselves, it took over two years before they actually committed to a career change program.

The first impression of engineering for these women was not overwhelmingly positive. In addition, some were actively discouraged from pursuing a career in engineering. Table 2 shows these numbers.

<table>
<thead>
<tr>
<th>First impression of engineering</th>
<th>Negative</th>
<th>Neutral</th>
<th>Positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Classes</td>
<td>10</td>
<td>6</td>
<td>9</td>
</tr>
<tr>
<td>Last Class</td>
<td>6</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Discouraged from career in engineering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Classes</td>
<td></td>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td>Last Class</td>
<td></td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

The table shows that, unfortunately, the impressions and encouragement of engineering as a career deteriorated over the seven or eight years between the two groups. The negative impressions of the first class fell into two broad categories: that it was too technical (not people-oriented) and boring and that it was for men and too difficult for women. One woman thought that engineers were boring people who sat in a room with slide rules. Those that had positive impressions viewed engineering as a difficult discipline, but one to be admired. Discouragement for this group ranged from a grandmother who strongly felt that engineering was only for men to an engineering professor who maintained that women were more "welcome" and did better in the fields of science than in engineering. One woman discovered during high school that she had an aptitude and love of geometry. She aspired to be an engineer. When she made plans to major in engineering in college, her father who was an engineer put a complete block on the whole plan. He did not feel that women had any place in the engineering field and he would not support his daughter in college if she were to major in engineering. He would support her if she majored in women in engineering conference: a national initiative 1991 WEPAN National Conference
mathematics and made plans to become a math teacher. The woman majored in mathematics. Over twenty years later she returned to school through the Graduate Career Change Program and fulfilled her dream by receiving a Masters degree in engineering.

The negative first impressions of the last class included: too theoretical, engineers just did math all day long (boring), engineers just built bridges or invented things (not people-oriented), and that engineering was a masculine field, not appropriate for women. The positive impressions were that engineering was interesting and respectable, highly technical, and "yes, that's for me." Discouragement came from a high school counselor who advised that engineering was a "man's profession," from a high school math teacher who told the student that she had poor math conceptual understanding, and a second high school counselor who asked the young woman who wanted to be an engineer to drop out of the drafting class, which was the first class recommended for an engineering track. She was asked to drop because a boy wanted to take the class! She was assigned to a history class, which she hated, and received a C to blemish her otherwise perfect all A record through all of high school.

Sixty-eight percent of the participants in the first career change class(es) were married. Fifty percent of the women in the last class were married and an additional 30% were single parents. In the 1988 SWE survey, 81% of the men and 54% of the women were married.

For information on the preferred learning styles of these career change engineering women, see [6]. This paper compares their preferred learning styles to the preferred learning styles of engineering students in general, engineering freshman and engineering professors. The preferred learning styles are also contrasted with the preferred teaching styles of engineering professors.

Career Change Women Engineers Perceptions

We now return to the question of how an engineer compares with an "average" person. More specifically, how does a career change woman engineer compare with the population as a whole and with an "average" male engineer? The career change women, who were surveyed, were asked how they perceived themselves relative to the population as a whole in the five main categories used by Koen to characterize engineers. In each category, the career change woman engineer was asked to rank herself on a scale of 1 to 10. The results are as follows:
TABLE 3
CAREER CHANGE WOMEN ENGINEERS PERCEPTIONS

Compared with the population as a whole, how do you consider yourself?

1. Not well-read = 1  Well-read = 10
   First Class ave. 7.44
   Last Class ave. 8.10
   All Engineers Not well-read

2. Poor Family Member = 1  Good Family Member = 10
   First Class ave. 8.68
   Last Class ave. 9.56
   All Engineers Good Family Member

3. Conservative Politically = 1  Liberal Politically = 10
   First Class ave. 5.36
   Last Class ave. 4.90
   All Engineers Conservative Politically

4. In making a decision, use:
   Numbers = 1  General Philosophy = 10
   First Class ave. 5.13
   Last Class ave. 5.40
   All Engineers Numbers

5. Not Goal Oriented = 1  Goal Oriented = 10
   First Class ave. 8.04
   Last Class ave. 8.20
   All Engineers Goal Oriented

The self perceptions of the two groups of career change women are remarkably similar. In the categories of "good family member" and "goal oriented," the career change women are similar to the general engineers category. Although studies show that the average (male) engineers are not well-read, the career change engineering women consider themselves to be quite well-read. Although engineers in general are politically conservative, the career change women engineers, on the average, perceive themselves to be "middle of the road" politically. Engineers primarily use numbers to make a decision, but the career change women engineers appear to use both numbers and general philosophy in making a decision. This "dual" decision process may be a function of a woman's increased abundance of left brain-right brain connecting fibers.
As engineers solve problems, they bring their view to bear when they "choose important aspects of a problem and their relative importance." Since an engineer is not an "average person," "at times his model will not adequately represent society." [1] As Koen points out, the general characteristics of an engineer may change in the future. As more women enter the engineering field, it appears that some of these characteristics will be changed by their presence.

REFERENCES


