NASA/DoD Aerospace Knowledge Diffusion Research Project

Paper Forty Nine

Becoming an Aerospace Engineer: A Cross-Gender Comparison

Reprinted from the Journal of Engineering Education
Volume 84, Number 3 (July 1995): 263-270

Laura M. Hecht
Indiana University
Bloomington, Indiana

Thomas E. Pinelli
NASA Langley Research Center
Hampton, Virginia

Rebecca O. Barclay
Electronic Information Age, Inc
Portsmouth, Virginia

John M. Kennedy
Indiana University
Bloomington, Indiana

National Aeronautics and Space Administration

Department of Defense

INDIANA UNIVERSITY

Becoming an Aerospace Engineer: A Cross-Gender Comparison

LAURA FRYE HECHT
Indiana University

THOMAS E. PINELLI
NASA Langley Research Center

REBECCA O. BARCLAY
Electronic Information Age, Inc.

JOHN M. KENNEDY
Indiana University

ABSTRACT

We conducted a mail (self-reported) survey of 4300 student members of the American Institute of Aeronautics and Astronautics (AIAA) during the spring of 1993 as a Phase 3 activity of the NASA/DoD Aerospace Knowledge Diffusion Research Project. The survey was designed to explore students' career goals and aspirations, communications skills training, and their use of information sources, products, and services. We received 1723 completed questionnaires for an adjusted response rate of 42%. In this article, we compare the responses of female and male aerospace engineering students in the context of two general aspects of their educational experience. First, we explore the extent to which women and men differ in regard to factors that lead to the choice to study aerospace engineering, their current level of satisfaction with that choice, and their career-related goals and aspirations. Second, we examine students' responses to questions about communications skills training and the helpfulness of that training, and their use of and the importance to them of selected information sources, products, and services. The cross-gender comparison revealed more similarities than differences. Female students appear to be more satisfied than their male counterparts with the decision to major in aerospace engineering. Both female and male student respondents consider communications skills important for professional success, but females place a higher value than males do on oral communications skills. Women students also place a higher value than men do on the roles of other students and faculty members in satisfying their needs for information.

I. INTRODUCTION

This article describes the similarities and differences between female and male aerospace engineering students in the context of two general aspects of the educational experience. First, we explore the extent to which men and women differ in regard to factors that lead to the choice to study aerospace engineering, their current level of satisfaction with that choice, and their career-related goals and aspirations. Second, we are interested in students' preparation for working with scientific and technical information (STI). Engineers' skills in using and communicating STI are valued highly by their employers. We compare the responses of female and male students on the basis of their training in working with and communicating STI, as well as the STI sources and products they use most frequently in meeting their engineering information needs.

II. BACKGROUND

Despite rapid increases in recent years, the proportion of engineering degrees awarded in the United States (U.S.) to women remains low compared with the percentage of degrees earned by women in other scientific and technical fields. Of the bachelor's degrees awarded in 1988 in the U.S., women earned about 47% of the degrees in mathematics, 36% of computer science degrees, and 30% of physical science degrees, but only 14% of engineering degrees.[1] Previous research suggests that the timing of the career decision and the quality of career counseling received are two factors that result in low enrollments of women in engineering. According to Jagacinski,[2] male engineers make the decision to become engineers earlier in their academic careers than female engineers do. Counselors may be more inclined to encourage male students than female students to pursue engineering if they show an aptitude for mathematics and science.[3] Once they are enrolled in engineering programs, women change to other majors at a higher rate than men change. This higher rate of attrition occurs even when such factors as social support, current and past academic performance, and parents' educational attainment are controlled.[4]

Two dimensions of the engineering educational experience are described in this article. The first dimension concerns the path taken in choosing the (aerospace) engineering major and students' expectations of a future in their chosen career. We explore the extent to which gender differences exist in the timing of the decision to study aerospace engineering, the factors which influenced that choice, and students' current level of satisfaction with the choice to study aerospace engineering. Students' evaluations of the importance of a range of career goals are also reported.

The second dimension relates to the communications skills training (i.e., writing, making oral presentations, and searching for and acquiring information) students receive as part of their academic preparation. Industry surveys indicate that potential employers

consider engineers' communications skills (i.e., writing, oral presentations, and the ability to search and acquire information) at least as important as their technical skills.[5-11] Skills in communicating technical information to others effectively, both orally and in written form, as well as ease in accessing and using existing information are essential components of an engineer's training. Accordingly, male and female aerospace engineering students' attitudes about the importance of these skills in ensuring professional success are explored. The extent of and perceived helpfulness of communications skills training are discussed as well. Students' patterns of information seeking and use are described by examining their use of and the importance to them of selected STI sources and products.

The data analyzed in this paper were collected during one phase of a larger study, the *NASA/DoD Aerospace Knowledge Diffusion Research Project*, which was undertaken to gain a better understanding of the methods that aerospace engineers and scientists use to locate, use, produce, and communicate STI. The position of the United States (U.S.) as a world leader in the aerospace industry depends in large part on maintaining and improving the competence of aerospace engineers and scientists. The ability of U.S. aerospace engineers and scientists to acquire and utilize the results of the latest aerospace research and development findings is a major factor in enhancing innovation and productivity within that industry.[12]

The Project was conducted in four phases. Phase 1 focuses on the information-seeking practices of U.S. aerospace engineers and scientists. Phase 2, which surveyed aerospace librarians in government and industry, is designed to explore how federally funded research and development results are distributed. Phase 3 examines the transfer of aerospace research and development knowledge within the academic sector. This paper reports the results of a Phase 3 survey. Phase 4 explores the information-seeking behaviors of aerospace engineers and scientists outside the U.S.[13]

III. Methods

This paper analyzes data collected from student members of the American Institute of Aeronautics and Astronautics (AIAA)* Self-administered (self-reported) questionnaires were mailed to a sample of 4300 AIAA student members during the spring of 1993. By September 23, the cut-off date, 1723 questionnaires were completed and returned. After adjusting the original sample size for incorrect addresses, the response rate was 42%. The final sample includes 1447 male students (83%) and 276 female students (17%).**

IV. Presentation of the Data

The educational experiences of female and male students are described below. The extent to which differences in experiences and attributes vary systematically with gender is tested using the chi-square statistic. A significant chi-square result ($p < .05$) indicates that it is unlikely that differences between men and women in the distribution of responses can be attributed to chance alone; that is, students' reports of their experiences are influenced by their gender.

A. Career Choice and Expectations

We compared women and men on the basis of the timing of the decision to study aerospace engineering, the factors that affected the decision, and the current level of satisfaction with the career choice. Men's and women's ratings of the importance of a range of career goals are described as well.

Jagacinski's[14] research on employed engineers showed that men had made their career decisions earlier than women had, although the gender difference was less apparent among newer cohorts of engineers. While it appears that the proportion of women who decide to become engineers at an early age is increasing, there is no significant difference between female and male AIAA student members in the timing of the decision to study aerospace engineering (Table 1). Most students had made their career choices prior to starting college. Over 78% of the women and 72% of the men had made a

*Because AIAA student members are a self-selected group, one must exercise caution in generalizing the results of this survey to all U.S. aerospace engineering students. Similar surveys were conducted among engineering and science students attending the University of Illinois, Texas A&M, and technology education students at Bowling Green State University. Aerospace engineering students in India, Japan, and Russia were also surveyed. Data from these surveys will be analyzed and presented in subsequent papers.

**The percentage of women who responded to the AIAA survey is slightly higher than the percentage of women respondents to the same survey conducted among engineering and science students at the University of Illinois at Champaign-Urbana (16.7%), aerospace engineering students at Texas A&M (13%), and technology students at Bowling Green State University (13.2%).

Decision Point	Females (n = 276)		Males (n = 1447)	
	%	n	%	n
Elementary School	14.5	40	13.2	189
High School	64.0	176	59.3	852
When Starting College	9.8	27	11.9	171
After Starting College	8.4	23	11.4	164
Other	3.3	9	4.2	61

Table 1. Timing of decision to study aerospace engineering.

career choice while in high school or elementary school.

Students were asked to rate the importance of several factors in influencing their decisions to study aerospace engineering. The percentages of men and women who regard these factors as important are listed in Table 2. The most important factor for both men and women was the desire for a career with rewarding opportunities (81% of men and 85% of women). This was the only factor on which women's and men's importance ratings did not differ significantly. For women, the second most important factor was the availability of information regarding career opportunities in engineering; 37% of women rated this as an important factor, compared with only 23% of men. This access to information about careers in engineering may be one factor that prompts women's choices to study engineering earlier in their academic careers.

The expected financial benefits of a career in engineering was the second most important factor for men (26%), although significantly more women rated this factor important (32%). Women were significantly more likely than men to report that the influence of others—teachers, parents, and other family members—was an important factor that contributed to their career choices (X^2 is significant at p .05).

Students were also asked to rate their current level of satisfaction with career choice relative to their happiness at the time they chose aerospace engineering (Table 3). Overall, female undergraduate students are happier than male undergraduates with their career choices. Over 36% of the women reported that they are happier

Factor	Females (n = 276)		Males (n = 1447)	
	%[a]	n	%[a]	n
Parents	22.9	59	14.1	190*
Other Family	12.7	31	7.2	95*
Teachers	26.1	66	14.5	196*
Leads To Financial Security	32.3	88	26.4	375*
Career With Rewarding Activities	84.6	231	80.9	1161
Information On Career Opportunities	37.2	100	23.4	324*

[a]Factors were rated using a 7-point scale where 7 indicates the highest importance rating. The percentages listed include students who rated the factor as either a 6 or 7.

*X^2 is significant at p ≤ .05 (d.f. = 6).

Table 2. Factors that influenced career choice of aerospace engineering.

Level of Satisfaction	< Senior		Senior		Total*	
	%	n	%	n	%	n
Females						
More Happy Now	33.7	32	37.3	28	35.3	60
Equally Happy Now	50.5	48	38.7	29	45.3	77
Less Happy Now	15.8	15	24.0	18	19.4	33
X^2 is significant at p = 0.23 (d.f. = 2).						
Males						
More Happy Now	28.3	90	26.3	118	27.1	208
Equally Happy Now	53.8	171	43.4	195	47.7	366
Less Happy Now	17.9	57	30.3	136	25.2	193
X^2 is significant at p = 0.00 (d.f. = 2).						

* Total difference in happiness by gender: X^2 is significant at p ≤ .07 (d.f. = 2).

Table 3. Current level of satisfaction with career choice relative to happiness at time of choice (undergraduates only).

with their career choices now than when they made them, compared with only about 27% of the men. Just under 22% of women and 28% of men are less happy now than when they made their choices. This change over time in happiness with career choice appears to vary with a student's academic year. For both men and women, a greater percentage of seniors reported that they were less happy now with their career choices than when they made them. Nevertheless, 76% of female seniors were currently as happy or happier with their career choices than when they made the choices; less than 70% of male seniors were currently as happy or happier with their career choices.

The difference in relative happiness among men based on their class standing is significant, while the difference for women is not. A greater percentage of male seniors, compared to males in their sophomore and junior years, are less happy with their career choices now than when they made them. This finding may reflect male students' perception of limited job opportunities in aerospace.[15] The constriction of job opportunities in aerospace may not affect women in the same way. Female engineering graduates are actively recruited by employers, particularly those firms which receive government contracts and which seek to hire more women to diversify their engineering staffs and respond to affirmative action goals.[16]

Female students drop out of engineering programs at higher rates than male students do. Adams'[17] survey suggests that female engineering students are more likely than males to doubt their abilities when faced with even minor failings, regardless of their academic records. Because the field of engineering is already defined as appropriate for men, men are less likely than women to be sensitive about their engineering competencies. As a result, women may transfer out of engineering more readily than men do.

A pattern of higher attrition rates for women is seen among AIAA student members who participated in this study* (Table 4). During the sophomore year, nearly 27% of student members of the AIAA are women. This proportion falls steadily as the year of matriculation rises. By the senior year, only 14% of AIAA student members are women, and women comprise only 13% of graduate aerospace engineering students in the AIAA sample.

*Whether this pattern accurately represents the proportion of all aerospace engineering students who are women or is a reflection of patterns of AIAA student membership is not known.

The greater likelihood of women compared to men remaining happy with their career choices may be a function of higher attrition rates instead of, or in addition to, a more confident outlook on potential job opportunities. If women are more apt than men to transfer out of an engineering program when they become disillusioned,[18] those who remain will tend to be only those women who continue to be satisfied with their career choices.

The AIAA students' ratings of the importance of a range of career goals and aspirations are reported in Table 5. These goals are organized broadly into three general categories: engineering (choices a-e), science (choices f-i), and management (choices j-o). Male and female AIAA student members are indistinguishable with regard to career goals; there is no significant difference between the importance ratings reported by female and male students. Those goals that are engineering related (i.e., to the use and application of new technologies) received the highest importance ratings. Approximately 84% of the students indicated that having the opportunity to explore new technological ideas is an important factor for a successful career. About two-thirds thought that working on complex technological problems is important to career success. A somewhat greater percentage of women than men gave high importance ratings to learning new technological knowledge (74% compared to 69%) and utilizing the latest theoretical results in their work (64% compared to 56%), but these differences were not significant.

These students consider developing a professional reputation and assuming management responsibilities less important than the technological aspects of the job in ensuring a successful career. About half of the students in this study thought that being evaluated on the basis of their technical contributions and establishing a reputation outside their own organization were important goals; however, fewer than half of these students regarded the written or oral communication of their ideas and achievements important to achieving success in their careers. Only about one-third of these students rated advancement to a policy-making position an important factor in defining a successful career; management positions related to directing and planning technical projects were rated somewhat more highly.

B. Communications Skills Training and the Use of STI

Much engineering work is geared toward devising creative solutions to complex technological problems; therefore, access to STI is crucial.[19] Employers expect engineers to have the skills needed to pro-

	Females (n = 276)		Males (n = 1447)	
Year In School	%	n	%	n
Undergraduate	**18.2**	**172**	**81.8**	**775**
Freshman	21.1	15	78.9	56
Sophomore	26.8	34	73.2	93
Junior	21.6	47	78.4	171
Senior	14.3	76	85.7	455
Graduate	**13.0**	**92**	**87.0**	**614**
Other	**15.9**	**11**	**84.1**	**58**

Table 4. Gender distribution of AIAA student members by year in school.

duce, transfer, and use STI, and students are aware of the importance of these skills. Over 80% of the students surveyed reported that communications skills and knowing how to use engineering and science information and materials are important to their professional success (Table 6). About two-thirds had received training in the use of engineering and science information and materials, although only about half of the students who had received training believed that the training was helpful.* A greater percentage of women than men reported that skills in using engineering and science information and materials were important (85% of women compared to 79% of men) and that their training experience was helpful (53% of women and 43% of men); however, these differences are not significant.

In addition to being skilled in using information, engineers must also be skilled in effectively communicating information. These skills are highly valued by prospective employers, who exhort academic engineering departments to train better students in written and oral communications skills.[20-24]

AIAA student members realize the importance of communications skills; between 80% and 90% of these students reported that written and oral communications skills were important to their future careers as aerospace engineers. Most students had received some type of training in communications skills. More than 72% had been trained in written communication. The percentage of students who had received training in oral communication skills was somewhat lower—just under 64% of women and nearly 62% of men were trained in oral communication skills.* Slightly over half of the students who had received training in written and oral communications skills reported that the training had been helpful.

Male and female students exhibit no significant difference in attitudes about the importance of technical writing skills or the helpfulness of technical writing instruction. In contrast, female students rate the ability to present information orally more highly than male students do. Nearly 90% of women consider oral communication skills important, compared to less than 83% of men. Of students who had received training in giving oral presentations, significantly more women reported that the training had been helpful (62% of women; 52.3% of men).

The AIAA survey also collected data on the information sources and products that students use to meet their information needs. The percentages of women and men who frequently use these information sources and products, as well as the percent who rated them important, are reported in Table 7. Most students in this study use their

*The reported percentages of students who received instruction include all under-graduates; many students who had not received training will have done so by the time they graduate. Approximately 72% of seniors received training in using engineering and science information resources and materials.

*Of the AIAA student members who were seniors, 83% had received instruction in written technical communication; 69% had received instruction in oral communication.

Career Goals and Aspirations	Females (n = 276)		Males (n = 1447)	
	%[b]	n	%[b]	n
(a) Explore New Technology Or Systems	83.9	229	84.4	1212
(b) Work On Complex Technical Problems	65.5	180	66.5	958
(c) Learning New Technical Knowledge	74.4	203	69.2	998
(d) Utilize The Latest Theoretical Results	64.2	176	56.3	807
(e) Receive Patents	26.2	70	24.8	350
(f) Be Evaluated On Technical Contributions	55.0	148	52.7	752
(g) Establish Reputation Outside Organization	57.7	157	49.9	714
(h) Publish Articles In Technical Journals	38.5	104	37.3	534
(i) Present Papers At Professional Meetings	43.0	117	40.7	586
(j) Technical Leader Of Less Experienced Professionals	47.6	127	46.7	667
(k) Attain A High-Level Staff Technical Position	52.4	140	49.4	703
(l) Plan And Coordinate The Work Of Others	42.2	113	39.5	561
(m) Become A Manager Or Director	42.7	114	40.5	574
(n) Plan Projects Affecting The Organization	52.7	143	48.8	695
(o) Advance To A Policy-Making Position	32.7	87	35.4	499

[a]Chi-square tests were run on for each factor; none were significant at $p \leq .05$ (d.f. = 6).

[b]Career goals and aspirations were rated using a 7-point scale where 7 indicates the highest importance rating. The percentages listed include students who rated the career goals and aspiration as either a 6 or 7.

Table 5. Importance of career goals and aspirations.

personal collections of information in order to satisfy their information needs; about three-fourths of the students frequently use their own collections to satisfy information needs. The second most frequently used source of information for the women in this study is other students (59%), followed by consultation with faculty members (52%) and, lastly, the library (35%). Men use the library to locate information (41%) more often than they consult faculty members (38%). A personal collection of information is the source rated most important, followed by consultation with faculty members. More men than women rate the library an important source of information, whereas women value other students more highly than the library as an important information source.

Male and female students in this study show little difference in the extent to which they use their personal collections of information or the library as sources for satisfying information needs. In contrast, significant differences exist between these men and women in the use and importance of other students and faculty members as sources of information. Women are significantly more likely than men to consult other students and faculty members; women also assign higher importance ratings to these information sources.

Men and women in this study do not differ significantly in the frequency of their use of selected information products or in their assessment of the importance of these products. As expected, students most frequently use textbooks. Nearly 87% of these women and over 83% of these men consult textbooks frequently; 81% of women and 76% of men rate textbooks an important information product. Journal articles are the next most frequently used information product. More than 40% of these students frequently consult journal articles and rate them important. About one-third frequently use handbooks; slightly fewer report using technical reports and conference papers on a regular basis.

V. Summary

Women remain a small minority of engineering students; nevertheless, a comparison of male and female aerospace engineering students reveals more similarities than differences. Based on her 1981 survey, Jagacinski[25] found that the men in her sample had made their career decisions at earlier ages than the women did. In contrast, the male and female AIAA student members who responded to the present survey had made their career choices at about the same stages in their academic careers. The finding that male and female AIAA student members demonstrate the same patterns of goals and aspirations is consistent with Jagacinski's earlier finding, however.

Female students also appear to be happier than males with their career choices, regardless of class standing. However, it is unclear whether women are simply happier with their choices than men, or whether this survey failed to reach women who were unhappy with the choice of the engineering major. For example, women may be

Skills	Females (n = 276)		Males (n = 1447)	
	%[a]	n	%[a]	n
Using Engineering/Science Information and Materials				
Importance To Career	85.4	151	79.2	1132
Received Training	64.2	176	63.3	910
Helpfulness Of Training	53.5	92	43.2	397
Technical Writing				
Importance To Career	87.5	239	83.0	1192
Received Training	73.1	201	72.0	1034
Helpfulness Of Training	58.5	117	52.7	545
Oral Presentations				
Importance To Career	89.1	244	82.5	1184*
Received Training	63.6	175	61.9	890
Helpfulness Of Training	62.0	109	52.3	473*

[a]Importance and helpfulness were rated using a 7-point scale where 7 indicates the highest ratings for importance and helpfulness. The percentages listed include students who rated importance and helpfulness as either a 6 or 7. **Note**: Helpfulness percentages are based only on the responses of those students who had received instruction in the selected communications skill.

*X^2 is significant at $p \leq .05$ (d.f. = 6).

Table 6. Selected communication skills: importance of skills to career success; receipt and helpfulness of instruction.

more likely than men to change to another major when they become dissatisfied.*

The few gender differences that were found to be significant follow an interesting pattern. Jagacinski[26] had reported that there was no difference between male and female professional engineers in the extent to which "people factors" (such as friends, relatives, and counselors) had influenced their career choices. Among the AIAA student members in this study, however, females were more likely than males to credit the influences of others (parents, teachers, and other family members) as important factors in helping them decide to pursue engineering. Female students in this study seem to value direct communication with others more highly than men do, whereas male students appear to have more individualized approaches to their preparation for professional life. Most of these students, both female and male, consider the acquisition of communications skills important to ensuring professional success, but the female students place a higher value than males do on oral communication skills. Women also place a higher value than men do on the roles of others (other students and faculty members) in the effort to satisfy information needs; they also consult these sources more frequently than men do. Most AIAA student members understand the importance of communications skills for professional success, and most reported receiving training or coursework in these areas. Given the emphasis in industry on working in groups and on oral, as well as written, communication skills, female graduates are perhaps better prepared for meeting employers' expectations as professional engineers. This factor may give women an initial labor market advantage. The advantage may be limited to the short term, however, if the "culture of engineering" is such that these behavioral styles invite negative consequences during day-to-day interaction.*[27-28]

Finally, the male and female AIAA student members in this study appear to be more alike than they are different in their atti-

*Another plausible explanation for the greater difference in satisfaction with the choice to study engineering is that women who are less happy with their choice of major may be less likely than men to become student members of a professional (technical) organization like the AIAA, and so would not have appeared in the sample of AIAA students surveyed. However, preliminary analysis of data from surveys conducted at Texas A&M University and the University of Illinois, in which all students enrolled in aerospace engineering were eligible to participate, indicate that female students do, in fact, tend to be happier with their career choices than their male colleagues appear to be.

*Robinson and McIlwee (1991)[27] argue that the culture of engineering, maintained through workplace norms and values that organize the patterns of day to day interaction, is defined by men to serve male interests. Women's behavioral and interactional styles that deviate from established norms may lead to professional marginalization. The problem is exacerbated in firms where engineers have a high degree of power. In these settings, norms consistent with a culture of engineering that favors male interests can be imposed more rigorously by the engineers themselves. In firms where engineers are less powerful in relation to management (mainly, in large bureaucratic firms subject to affirmative action regulation), the influence of the culture of engineering is weaker. Here, women's failure to conform to the culture of engineering has fewer negative consequences for career advancement and may even confer added benefits.

	Use		Importance	
	Female (n = 276)	Male (n = 1447)	Female (n = 276)	Male (n = 1447)
Information Sources and Products	%[a]	%[a]	%[b]	%[b]
Sources				
Personal Collection	72.5	77.2	64.7	71.3
Other Students	59.4	41.9*	46.7	32.3*
Faculty Members	52.4	38.8*	58.1	44.9*
Library	35.4	41.3	39.2	40.5
Products				
Textbooks	86.7	83.4	80.6	75.7
Journal Articles	44.5	42.1	45.3	41.0
Handbooks	31.2	29.6	35.0	32.3
Technical Reports	29.7	26.3	32.4	28.0
Conference Papers	29.0	27.1	29.0	28.0

[a]Use percentages are based on students who reported that they use the source or product frequently.

[b]Importance was rated using a 7-point scale where 7 indicates the highest importance rating. The percentages listed include students who rated the source or factor as either a 6 or 7.

*X^2 is significant at $p \leq .05$. (Use: d.f. = 4; Importance: d.f. = 6).

Table 7. Use and importance of selected information sources and products.

tudes toward and their preparation for careers in aerospace engineering. They share similar goals and aspirations for career development. Women appear to value oral communication skills more highly than men do, but these men and women are trained in oral communications skills in equal proportions. These women prefer to consult others for help in locating information more often than do these men, but these men and women ultimately satisfy their information needs by using the same information products. Further research would be required to assess whether these minor differences tend to distinguish male and female students' future career development.

Acknowledgements

The authors thank Ms. Barbara Lawrence, former Division Director-Technical Information, the American Institute of Aeronautics and Astronautics (AIAA), for making this study possible. We also thank the Council on Library Resources (CLR) and its former president, Dr. W. David Penniman, for providing the funds used to analyze these data.

References

1. National Science Foundation, *Women and Minorities in Science and Engineering*, Washington, DC: GPO, 1990.

2. Jagacinski, C.M., "Engineering Careers: Women in a Male Dominated Field," *Psychology of Women Quarterly*, vol.11, 1987, pp.97-110.

3. Brush, S.G., "Women in Science and Engineering," *American Scientist*, vol.79, 1991, pp.404-419.

4. Adams, D.W., *Factors Related to the Persistence of Men and Women Engineering Freshmen*, Ph.D. Diss., University of Pennsylvania, 1988, UMI 88-24705.

5. Morrow, R.M., "Issues Facing Engineering Education," *Journal of Engineering Education*, vol.83, no.1, 1994, pp.15-18.

6. Trick, T.N., "Educating Electrical and Computer Engineers for the Global Renaissance," *Journal of Engineering Education*, vol.83, no.1, 1994, pp.57-62.

7. Evans, D.L., et.al., "Attributes of Engineering Graduates and Their Impact on Curriculum Design," *Journal of Engineering Education*, vol.82, no.4, 1993, pp.203-211.

8. Strother, J.B., "Reality vs Expectations: Practicing Engineers vs Engineering Students," Paper presented at International Professional Communication Conference (IPCC), Santa Fe, NM. 1992.

9. Garry, F.W., "A Business Look at Engineering Education," *Engineering Education*, vol.76, no.4, 1986, pp.203-205.

10. Devon, R., "Industry's Advice for the First Two Years," *Engineering Education*, vol.76, no.2, 1985, pp.112-114.

11. Sylvester, N.D., "Engineering Education Must Improve the Communication Skills of

its Graduates," *Engineering Education*, vol.70, 1980, pp.739-740.

12. Pinelli, T.E., J.M. Kennedy, and R.O. Barclay, "The NASA/DoD Aerospace Knowledge Diffusion Project," *Government Information Quarterly*, vol.8, no.2, 1991, pp.219-233.

13. Pinelli, T.E., et al., "Aerospace Knowledge Diffusion Research," *World Aerospace Technology '91: The International Review of Aerospace Design and Development*, vol.1, 1991, pp.31-34.

14. Reference 2.

15. Kennedy, J.M., T.E. Pinelli, and R.O. Barclay, "Technical Communications in Aerospace Education: A Study of AIAA Student Members," Paper presented at the 32nd Aerospace Sciences Meeting & Exhibit of the American Institute of Aeronautics and Astronautics, Reno, January 1994, AIAA 94-0858.

16. McIlwee, J.S. and J.G. Robinson, *Women in Engineering: Gender, Power and Workplace Culture*, Albany, NY: State University of New York Press, 1992.

17. Reference 4.

18. Reference 4.

19. Pinelli, T.E., et al., "The Information-Seeking Behavior of Engineers," *Encyclopedia of Library and Information Science*, vol.52, no.15, 1993, pp.167-201.

20. Reference 7.

21. Reference 8.

22. Reference 9.

23. Reference 10.

24. Reference 11.

25. Reference 2.

26. Reference 2.

27. Robinson, J.G. and J.S. McIlwee, "Men, Women, and the Culture of Engineering," *Sociological Quarterly*, vol.32, no.3, 1991, pp.403-421.

28. Hacker, S., *Doing it the Hard Way: Investigations of Gender and Technology*, Boston: Unwin Hyman, 1990.