

# Student Perspectives on Engineering\*

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*First-year and fourth-year engineering students at the University of Western Ontario were surveyed for their attitudes towards engineering: pre-university, at university and afterwards. The responses were analysed by gender and by year for significant differences. The men decided on an engineering career earlier in their lives than the women, who often did not decide until they were at university. More of the men were encouraged in their choice of engineering by their fathers than the women were but, conversely, a higher percentage of the women had fathers who were engineers.*

*At university, the women tend to attribute academic difficulties to their own shortcomings whereas the men tend to blame external factors. More men than women found the faculty unapproachable, perhaps because of their own inferior communication skills. First-year students were interested in having senior students as mentors but, unexpectedly, the women students did not express a greater interest than the men. The only difference in career plans was that more women expressed an interest in working on environmental issues.*

## INTRODUCTION

DUE to the predicted shortage of Canadian engineers by the year 2000 [1], it is important to maximize the quality and number of engineers at Canadian universities. This means optimizing the entire engineering experience from the start for both women and men. The process of becoming an engineer is not just a university experience. The process starts sometime during the 18 years prior to entering an engineering programme and continues to develop and evolve indefinitely. Many studies focus on one of three stages of the engineering experience: pre-university, university, or post-university. However, since all three stages are irrevocably interconnected, they must have some dependence on each other. This paper reports student responses of their attitudes to each of these three stages.

In 1988, a study to explore the opinions of women in engineering was conducted by Rosati and Surry [2] at the University of Western Ontario (UWO). This was a survey of open-ended questions directed at first-year core UWO engineering students. Distinct female and male perspectives emerged, though the nature of the questions did not allow for statistical analysis. Their study confirmed the findings of a 1975-1976 survey of 42 US freshmen engineering schools [3] in that there were significant differences between the educational factors judged important by men and women. Based on the more interesting responses of the 1988 UWO survey, a new quantitative appraisal was formulated.

To obtain accurate information about the opinions of women in engineering, surveys were given to both freshmen and seniors, women and

men. The survey showed some surprising differences in opinion between first- and fourth-year students' responses, as well as a number of gender differences.

This paper studies the engineering students' view of the process of becoming an engineer. The pre-university experience is examined first, followed by the undergraduate experience and finally plans for the future. Because of the depth of this survey, only those questions with unexpected or significant differences in response will be presented. Possible interpretations are suggested for the discrepancies between the freshman-senior and male-female responses.

## PROCEDURE

Based on the results from the 1988 survey, Rosati and Surry constructed two virtually identical surveys for first- and fourth-year students. Seventy-four students enrolled in a compulsory first-year class, completed the survey in the spring of 1993. Of this sample group, 38 were women and 36 were men. From the senior level, 66 students, 30 women and 36 men, from one mandatory course and several elective fourth-year classes completed the survey in the spring of 1993.

The response of all four groups: first-year men, first-year women, fourth-year men and fourth-year women were analysed using LOTUS 123. A chi-square procedure comparing the total responses of the men to those of the women and those of the freshmen to those of the seniors was used. Some interesting differences and similarities evolved—these are the questions on which this paper will focus.

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### PRE-UNIVERSITY ATTITUDES

The first group of questions dealt in general with the students' experiences before entering the engineering programme at UWO. The questions considered family support as well as confidence and awareness of the engineering discipline.

Lack of awareness about engineering as a career for women is cited as an important factor in the low enrolment of women in engineering [3-7]. A shocking example from Alberta illustrates the problem. In that province only 14% of students had taken the prerequisites for engineering and of those only one-third were women [4]. In 1992, only 14% of engineering students in Canada were female compared to 45-50% females in law, medicine or commerce [4]. When the students surveyed at UWO were asked when they first started to think about becoming an engineer, there was a marked difference between the men's responses and those of women. Seventy-seven per cent of men had thought of engineering while in high school between grades 10 and 13, while only 70% of women had thought of it during the same period. More startling, however, is the number of women who started thinking of a career in engineering only after entering university or the workforce—22% of women decided to enter engineering when they were already at university, whereas only 8% of the men decided this late

( $P < 0.05$ ). This phenomenon is illustrated in Fig. 1, a bar graph comparing the percentages of men and women who decided on engineering as a career at different times during their education. The statistics and the graph confirm the hypothesis that women are not informed about engineering as a possible career early enough during the educational process. Earlier exposure to the opportunities available in engineering would help women to keep an open mind when selecting courses in high school. The importance of female role models at university has been stressed for students of engineering [6, 8]; however, this directive could also be useful for secondary and elementary school students. Exposure to female mathematics and science teachers would also be an encouragement for women to enter engineering.

Of the 138 students surveyed, only one student had a mother who was an engineer. However, the number of women whose fathers were engineers was significantly greater than the number of men whose fathers were engineers ( $P < 0.05$ )—55% of the women had a father who was an engineer, compared with only 31% of the men. This suggests a strong father-daughter relationship, with the woman receiving support from their fathers who have experienced the engineering programme and perhaps have fewer misconceptions of the atmosphere in the engineering field. This large

### First considered Engineering

as a possible Option

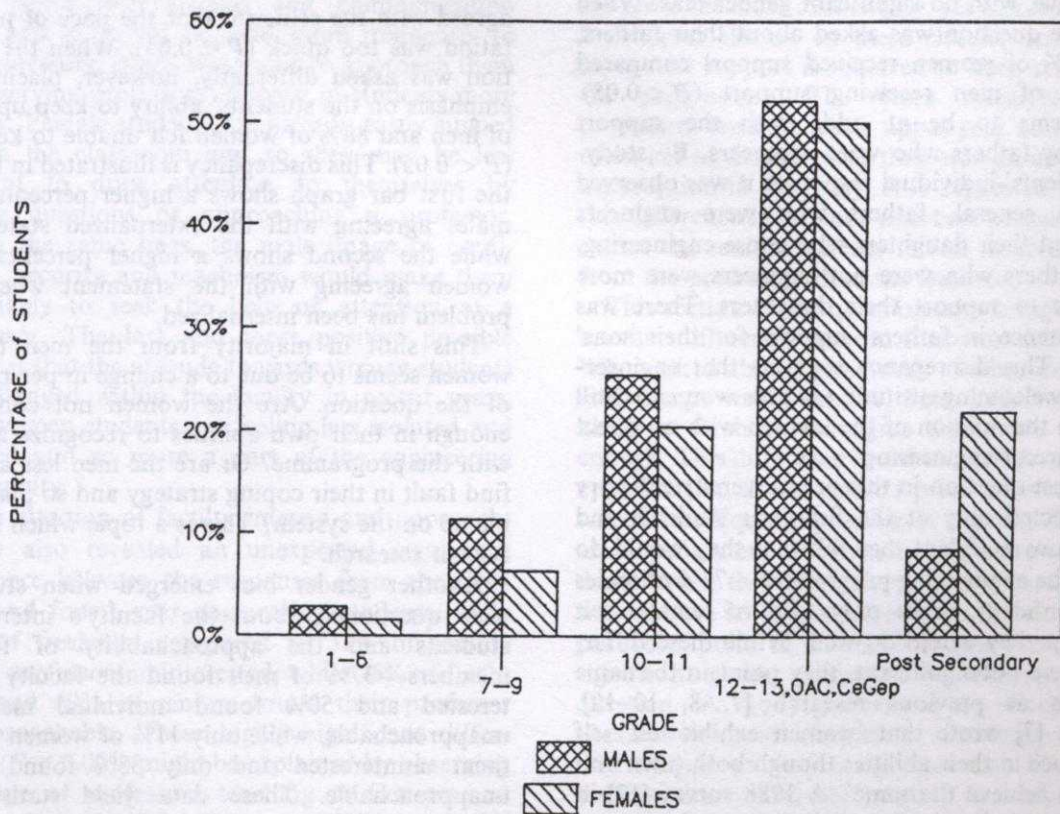


Fig. 1. Grade when engineering was first considered as a possible career.

difference also highlights the importance of exposure and role models for women.

Rosati and Surry's 1988 survey [2] of students suggested that women students depended more on encouragement from outside sources to make the decision to pursue studies in the male-dominated profession of engineering. When asked about having a relative who was an engineer and whether this person was a positive influence in the choice of engineering as a career, no gender bias was observed. There was, however, a difference ( $P < 0.05$ ) between the freshmen and the seniors responses—59% of the freshmen had experienced a positive influence, while only 33% of the seniors had. No such trend has been reported before. There are two suggested reasons for this difference. First, freshmen students who have entered engineering due to strong family influence rather than by their own initiative may never make it to the fourth year, losing interest or being unable to keep up. Another possible reason is that the seniors may no longer deem significant the nature of influences that initially caused them to enter engineering. It is also interesting to note that 47% of all the students responding to the survey did have a relative in the discipline.

Studies [5, 6, 9] often cite direct parental influence, regardless of the parent's profession as an important factor for determining whether to enter engineering or not. When questioned about their mothers' reaction to their decision to study engineering, the total of the engineering students surveyed reported that 82% of mothers were supportive, with no significant gender bias. When the same question was asked about their fathers, only 77% of women received support compared to 90% of men receiving support ( $P < 0.05$ ). This seems to be at odds with the support shown by fathers who were engineers. By studying students' individual responses it was observed that, in general, fathers who were engineers supported their daughters who chose engineering, while fathers who were not engineers were more reluctant to support their daughters. There was no difference in fathers' support for their sons' choices. This discrepancy suggests that engineering's unwelcoming attitude towards women is still intact in the opinion of the layman with no direct experience of engineering.

The last question in this pre-university category was directed only at the first-year students and asked how confident they felt that they would do well in the engineering programme—74% of males were confident, while only 51% of females felt confident they would do well. While these differences were not significant, they point in the same direction as previous research [7, 8, 10–12]. Deitrich [7] wrote that 'women exhibit less self confidence in their abilities though both (men and women) achieve the same'. A 1988 survey [12] in fact showed that 'women whose probable major was engineering had SAT mathematical scores

consistently higher than their male counterparts from 1980 until 1987'.

## ATTITUDES TOWARDS ENGINEERING AT UNIVERSITY

The second section of questions in the survey dealt with the students' experiences during the undergraduate engineering programme at UWO. Some interesting gender differences arose between the way women and men cope with problems. There was also some marked similarity in response to areas where a gender difference would be expected according to literature on the topic. A difference in opinion or experience between first- and fourth-year students in some examples could indicate that the programme is influencing the students.

In the 1988 survey by Rosati and Surry [2], it was noted that although males and females cited the same concerns about the engineering programme, men tended to 'assign an external source to their academic problems'. In contrast, women were more likely to 'accept personal responsibility for encountered problems'. Examples such as one man's worry: 'It would be hard', compared to a woman's concern: 'Whether I would be smart enough to become an engineer' illustrate this externalization versus internalization of problems. An example of this type of difference was evident in the second survey as well. When asked whether or not they agreed with a set of criticisms, 48% of men but only 27% of women agreed with the criticism that the pace of presentation was too quick ( $P < 0.05$ ). When the question was asked differently, however, placing the emphasis on the students' ability to keep up, 74% of men and 88% of women felt unable to keep up ( $P < 0.05$ ). This discrepancy is illustrated in Fig. 2, the first bar graph shows a higher percentage of males agreeing with the externalized statement, while the second shows a higher percentage of women agreeing with the statement when the problem has been internalized.

This shift in majority from the men to the women seems to be due to a change in perspective of the question. Are the women not confident enough in their own abilities to recognize a fault with the programme? Or are the men less able to find fault in their coping strategy and so place the blame on the system? This is a topic which merits further research.

Another gender bias emerged when students were questioned about the faculty's interest in students and the approachability of faculty members—37% of men found the faculty uninterested and 50% found individual members unapproachable, while only 11% of women found them uninterested and only 33% found them unapproachable. These data yield statistically significant differences. ( $P < 0.001$  and  $P < 0.05$ , respectively). Four main factors are thought to

## Externalization vs. Internalization

Pace vs. ability to keep up

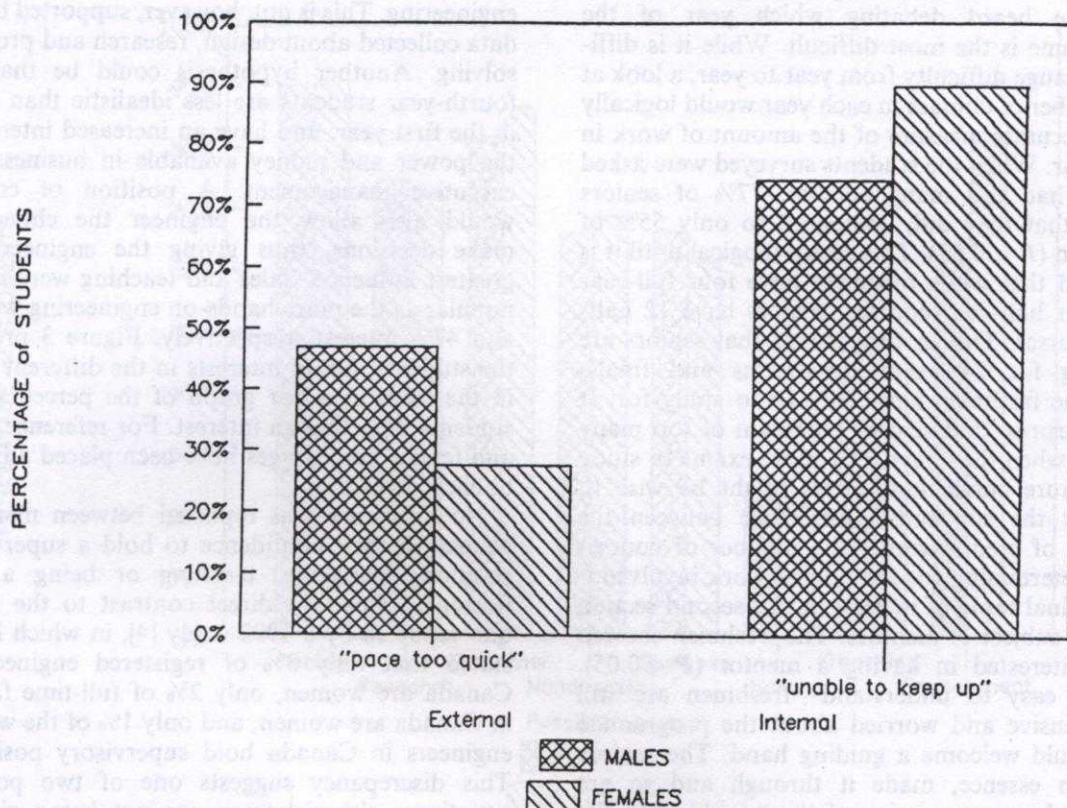


Fig. 2. Externalization or internalization of program difficulties.

influence this discrepancy. Women are thought to have better interpersonal and communication skills and so would respond more frequently to the professors; either being able to approach them or observing professors' interest in students more keenly. Female students are already easily singled out in the classroom and so they may be less hesitant to draw attention to themselves by asking questions or approaching a professor. Along the same lines, the male image of confidence, security and machoism would make them less likely to seek the help or attention of a professor. The last and most positive possible factor is that the attitude towards women students has changed within the faculty in recent years, thus women students are feeling less isolated and ignored and so more a part of the engineering community.

The question of faculty interest and approachability also revealed an unexpected significant difference between the responses from the first-year and fourth-year engineering students. Only 12% of freshmen compared to 37% of seniors found professors uninterested, while 26% of freshmen and 60% of seniors found their professor unapproachable. These highly significant differences ( $P < 0.001$ ) might be explained by observing the type of professors teaching in first-year as opposed to fourth-year courses. Professors who are intrinsically better teachers and who are

interested in the teaching process often choose or are given the more challenging, yet more rewarding lower-level classes. In these classes, professional input and support is required to keep students in the programme. The more research-oriented professors tend to teach upper-year courses and often act as though class time was an unwelcome interruption in their day. It is suggested that it is this difference in attitude and true interests which causes the senior students to feel more distanced from the professors than the freshmen.

This section of the questionnaire brings to light another difference between freshmen and seniors. When asked about the amount of laboratory work and design work, seniors were almost twice as likely as freshmen to agree that there was not enough. This difference could be a result of natural apprehension in the seniors prior to entering the workforce. Equally possible is that the freshmen are hopefully expecting more laboratory work and design when they reach the upper years, while the seniors have realized and accepted the shortage. A particular point of interest was that there was no significant gender difference in response to this question. A study performed by Cooney [10] about women in laboratory situations suggests that women are less likely than men to excel in the laboratory and are notably less self-assured than men in the laboratory. While women may not enjoy laboratories as much as men, it is reassuring

to see that women are no less interested in them and appear to appreciate their value.

Students within the engineering faculty can often be heard debating which year of the programme is the most difficult. While it is difficult to gauge difficulty from year to year, a look at the number of courses in each year would logically be an accurate measure of the amount of work in each year. When the students surveyed were asked if they had too many courses, 77% of seniors agreed that they did, compared to only 55% of freshmen ( $P < 0.01$ ). This seems illogical until it is observed that while freshmen have four full-year and four half-year courses, seniors have 12 half-year courses. This in turn means that seniors are studying for 24 exams (midterms and finals) while the freshmen have only 16 to study for. It is no surprise that seniors complain of too many courses when they have 33% more exams to study for. Future curriculum-setters might be wise to consider the substantial difference between the number of credits versus the number of courses when determining the amount of work involved.

The final topic of interest in this second section was the subject of mentors. The freshmen showed more interest in having a mentor ( $P < 0.05$ ). This is easy to understand—freshmen are still apprehensive and worried about the programme and would welcome a guiding hand. The seniors have, in essence, made it through and so are perhaps less appreciative of the possible benefits that might have accrued from a mentor relationship. There was no meaningful distinction in the desire for a mentor between women and men. This observation contradicts the report of Robinson and Reilly [8], which proposes that mentors would be of tremendous help to women, more so than for men.

This section of the survey confirmed some earlier findings and conceptions regarding the gender bias in the undergraduate engineering programme. A number of thought-provoking points were also raised about the differences between first- and fourth-year students.

#### ATTITUDES TOWARDS PROFESSIONAL PLANS

The final section of the survey questioned students about their reflections, plans and interests for the future regarding their work after graduation. Freshmen and seniors had contrasting ideas most often in this section.

Design, research and problem solving were all popular career choices, with overall student interest ratings of 91, 74 and 85%, respectively. No meaningful differences were evident between males and females, and freshmen and seniors. Management and business interests ranked slightly below the technical interests, with overall averages of 68 and 63.5% interest, respectively. Here there was a significant difference between the freshmen

and seniors, with the seniors showing more interest. At first sight this might suggest that the seniors had lost interest in the technical aspects of engineering. This is not, however, supported by the data collected about design, research and problem solving. Another hypothesis could be that the fourth-year students are less idealistic than those in the first year, and have an increased interest in the power and money available in business and executive management. A position of control would also allow the engineer the chance to make decisions, thus giving the engineers the greatest influence. Sales and teaching were not as popular as the more hands-on engineering with 23 and 47% interest, respectively. Figure 3 presents the students' future interests in the different fields in the form of a bar graph of the percentage of students reporting an interest. For reference, male and female percentages have been placed adjacent to each other.

No difference was reported between men and women in their confidence to hold a supervisory position, managing, teaching or being a professional. This is a direct contrast to the status quo reported by a 1992 study [4], in which it was stated that only 3% of registered engineers in Canada are women, only 2% of full-time faculty in Canada are women, and only 1% of the women engineers in Canada hold supervisory positions. This discrepancy suggests one of two possible situations: either women are not being given a fair chance, or else the situation is about to change with this new influx of women engineers.

The only gender disparity in terms of career choice which emerged from the survey was in the area of the environment—81% of women compared to 65% of men were interested in working on environmental issues. The most reasonable explanation for this interest is the humanitarian and compassionate outlook that the environment holds for women, perhaps more so than for men.

The survey also asked students if their career plans had changed since entering engineering at UWO. Not surprisingly, the number of seniors was much greater than the number of freshmen whose career options had changed ( $P < 0.01$ )—22% of freshmen and 45% of seniors had career plan changes; this was a higher percentage than would be expected. A future study should look at the reasons behind the changes.

#### CONCLUSIONS

Several main conclusions can be drawn from the gender differences which were apparent in the answers to the survey questions. First, it is clear women need more information and role models earlier on in their lives so that they might sooner begin to consider engineering as a possible career. Enlightening young women could be extended to informing their parents, especially the fathers who seem to discard the possibility of women entering a

## Career Interests

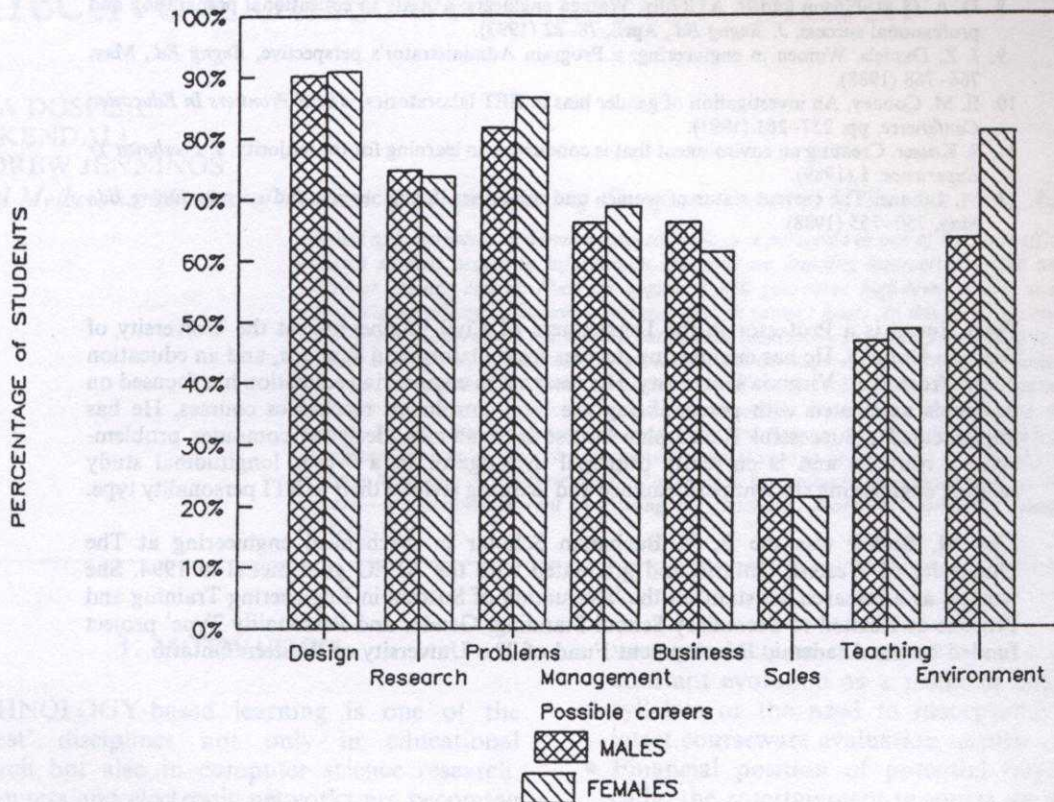


Fig. 3. Possible career interests.

traditionally male-dominated profession. Awareness must continue to be promoted during the undergraduate years in the engineering programme. Continued interest and approachability on the part of the professors is important, while the acquisition of female faculty is imperative. The initiation of a mentor programme would benefit all students in the programme. Further studies should be conducted to determine the depth of the difference created by the internalization of problems by women in comparison to the men's externalization. Is this discrepancy handicapping women and, if so, could it be relieved by implementing more diverse teaching styles or introducing more flexibility in the course structure, assessment and learning techniques? In order to help alleviate the upcoming shortage of engineers

and maintain Canada's global competitiveness, women engineers must be prepared, encouraged, and allowed the opportunity to hold supervisory, educational and management positions in Canada.

Comparisons between the views of the first- and fourth-year engineering students are relatively new. For this reason, the comments, criticisms and general differences presented in this paper are mainly of interest for the initiation of future studies. For example, it would be interesting to determine how teaching, workloads, and learning styles have evolved during immersion in the engineering programme. It would be useful to determine if engineers are shaped by the programme or choose the programme because of the way they are. The information from this study is a valuable base for future work.

## REFERENCES

1. M. Frize (Chair), *More Than Just Numbers*, Report of the Canadian Committee on Women in Engineering (April 1992).
2. P. A. Rosati and S. Surry, Female perspectives of engineering education: a qualitative assessment, *Int. J. Engng Ed.*, **10**, 164-170 (1994)
3. S. A. R. Garrod and M. R. Taber, Counselling women in engineering technology to prepare for their future, *ASEE Annual Conference Proceedings*, pp. 784-789 (1990).
4. S. McKay, Boy's club, *The Globe And Mail Report On Business Magazine*, pp. 37-44 (August 1992).
5. M. R. Anderson, Characterizations of the graduate career change woman in engineering: recruitment and retention, *ASEE Frontiers in Education Conference*, pp. 248-256 (1991).

6. R. I. Waite, Women in engineering: are we losing ground? *ASEE Frontiers in Education Conference*, pp. 232-247 (1991).
7. M. D. Ott, Sex differences in experiences and career plans of freshmen engineering students, *IEEE Transactions on Education*, E-21, pp. 230-233 (1978).
8. D. A. G. Robinson and B. A. Reilly, Women engineers: a study of educational preparation and professional success, *J. Engng Ed.*, April, 78-82 (1993).
9. J. Z. Daniels, Women in engineering: a Program Administrator's perspective, *Engng Ed.*, May, 766-768 (1988).
10. E. M. Cooney, An investigation of gender bias in EET laboratories, *ASEE Frontiers In Education Conference*, pp. 257-261 (1991).
11. S. Kossier, Creating an environment that is conducive to learning for the majority, *J. Freshmen Yr Experience*, 1 (1989).
12. M. J. Lane, The current status of women and minorities in engineering and science, *Engng Ed.*, May, 750-755 (1988).

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