Int. J. Engng Ed. Vol. 10, No. 2, pp. 164–170, 1994
Printed in Great Britain.

0742-0269/91 $3.00+0.00

Female Perspectives of Engineering Education: A Qualitative Assessment*

P. A. ROSATI
S. SURRY
Department of Civil Engineering, The University of Western Ontario, London, Canada N6A 5B9

A sample of the 1988 first year engineering class at the University of Western Ontario was surveyed for concerns and suggestions related to the engineering program. Distinct female and male perspectives emerged in the responses. Women students characteristically internalized perceived problems, while men identified a trouble source external to themselves. Also, women focused on non-academic issues as the aspects of the engineering program most significant to females. Men were much more likely to state academic concerns for criticisms. A traditionally large male majority in engineering schools suggests that these uniquely female perspectives may be unrecognized or ignored, unless actively sought and incorporated into the evolving program of engineering education.

INTRODUCTION

THE undergraduate career of a female engineering student is relatively brief in comparison with the minimum eighteen years before entering an engineering program, and possibly forty more afterwards as a practicing professional. This may partially explain why previous studies have focused on pre- or post-university experiences of young women, but seldom specifically considered their undergraduate years [1]. However short, the undergraduate years have significance beyond providing a woman's engineering education. This is the period when she may be making decisions about graduate studies, or simply whether or not to remain in the field of engineering. A woman student is also an excellent judge of currently appropriate strategies for recruiting her female peers into engineering schools. The predicted shortage of Canadian engineers by the year 2000 [2] means every opportunity for maximizing the number, quality, and diversity of future engineers should be explored.

In 1990, Grover surveyed university students' opinions about women in engineering at the University of Western Ontario [3]. No statistically significant difference was found between the responses of men and women engineering students, nor between women engineering students and non-engineering women students. A response rate of only 36% may have introduced a considerable but unknown bias.

An earlier study compiled the perspectives of men and women engineering students from forty-two US schools on freshman activities and career plans [4]: surveys were completed at the end of the freshman year by students who had entered in the fall of 1975, and a year later by those beginning the program in 1976. Consistent differences between men and women suggested factors of importance in the education of female engineers, including increased information about the nature of engineering careers.

Early in 1988, a survey was given to first-year engineering students at the University of Western Ontario to explore potentially gender-related views about the engineering program. This paper compares and contrasts overall female patterns of response with those of males, and offers possible interpretations of the findings. The small sample size dictated by the few women students, and subjective format of both questions and analysis, preclude the application of tests for statistical significance. However, the comments and impressions arising from the survey allow a qualitative assessment of the female perspective on UWO's engineering program, as distinct from the perspective of the male majority.

PROCEDURE

The survey sample was drawn from the core first-year class of about 300 people. Twenty-two of the thirty women in the class returned the questionnaire, and surveys were also completed by thirty-one male volunteers.

Questions were open-ended, asking students to express concerns, opinions, and recommendations about the first-year engineering program. Some questions specifically directed women to answer from the female perspective, and only women were asked whether they were 'concerned that female

* Paper accepted 1 April 1994.

students in engineering would be outnumbered ten-to-one by male students'.

The responses to the questions were considered verbatim, and then grouped into categories of response to look for trends. Not all study participants answered every question, and some gave two or more separate responses to the same query: twenty-one women completed question two, for example, but provided a total of thirty-one 'female responses'; twenty-nine men answered the corresponding question in the survey, resulting in thirty-eight 'male responses'.

RESULTS AND DISCUSSION

The results of this survey are limited to being of qualitative value because of the open-ended question style, and the subjectiveness of extracting and categorizing ideas from responses. Also, it is unclear whether a question left blank indicates the student had no pertinent concerns, for example, or just didn't bother to formulate an answer.

Outside support before and during undergraduate program

Each surveyed student was asked to choose from a given list the people who had provided positive encouragement to enrol in the University of Western Ontario's engineering program. A third of the men entered engineerinrg without any positive support from others, whereas all the women reported encouragement from some outside source. This fits with the hypothesis that men do not need outside support for their decision to study a male-dominated career field such as engineering: they may receive parental or societal encouragement, but often do not treat it as a factor in their career choice [1].

Other notable gender differences include: nearly 60% of females but less than 20% of males were encouraged to study engineering by their mothers; and no men, but almost a third of the women, received positive encouragement from a high-school science teacher. Daniels observed that it 'is an unusual young woman who will choose a career or school against the recommendations of her parents or respected teachers' [5] see also [1].

Many strategies for the retention of undergraduate women engineering students emphasize the importance of peer support groups, role models, and mentors within the engineering program [1, 4, 6, 7, 8]. Despite ample opportunity to raise such issues in the survey, women engineering students at the University of Western Ontario did not indicate that outside support would be useful to them in coping with the first-year program. The only related comments were made by three women who felt that a woman faculty member would be a valuable role model to undergraduates.

Internalization versus externalization

Regardless of sex, most students reported that their main concern about the engineering program both before entry and during their first year was of an academic nature. Upon the further subdivision (depicted in Figs 1 and 2), it was evident that the most prevalent academic concern anticipated before the first year was a heavy workload. Once in the program, the occurrence of worry about

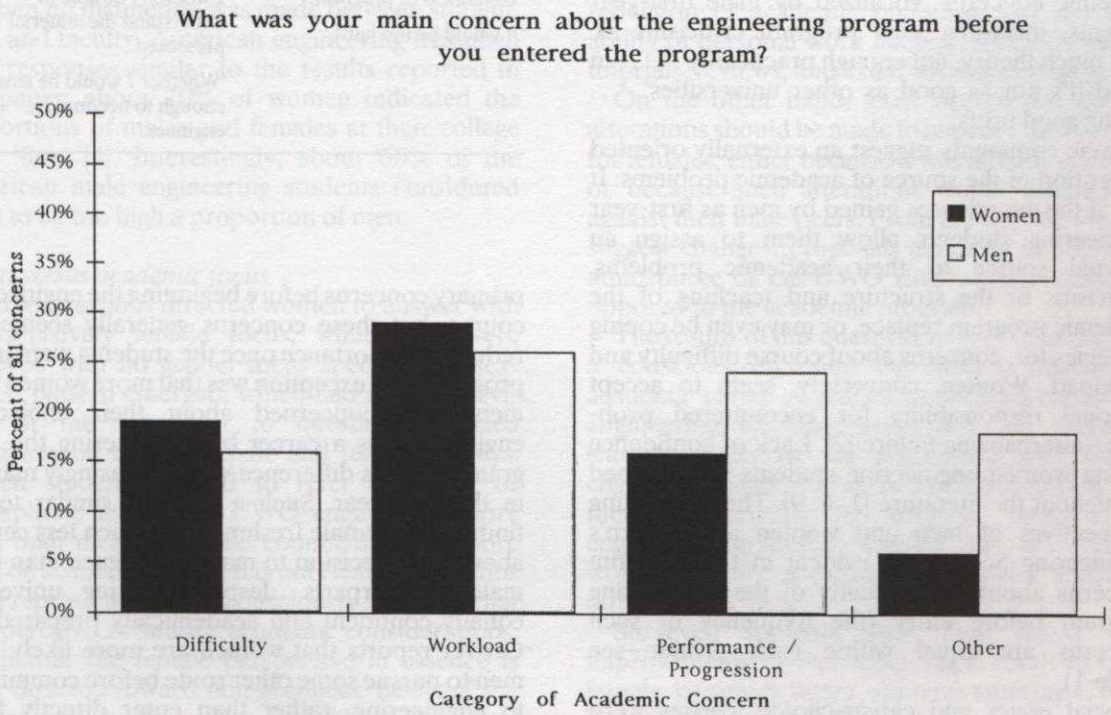

Fig. 1. Academic concerns about engineering program before commencement.

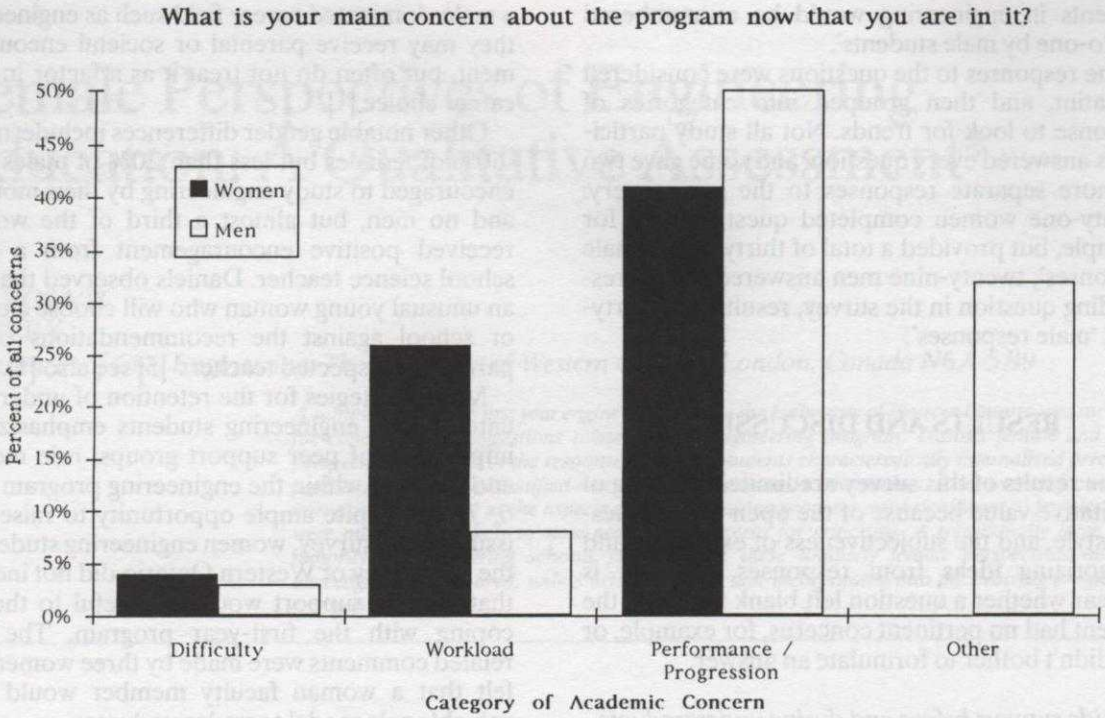

Fig. 2. Academic concerns about engineering program as experienced in the first year.

workload among men dropped and among women remained the same. As compared to expectations prior to enrollment, men and women in the first year expressed less concern about the difficulty of courses *per se*, and more concern specifically about their own performance or progression in the academic program.

It is interesting to note the shift toward 'other academic concerns' vocalized by male first-year students, including such program criticisms as: 'Too much theory, not enough practicality', '... I'm afraid it's not as good as other universities', '... getting good profs'.

These comments suggest an externally oriented perception of the source of academic problems. It is as if the experiences gained by men as first-year engineering students allow them to assign an external source to their academic problems. Criticisms of the structure and teaching of the academic program replace, or may even be coping strategies for, concerns about course difficulty and workload. Women, conversely, seem to accept personal responsibility for encountered problems—internalizing failure [2]. Lack of confidence among women engineering students is described throughout the literature [1, 6, 9]. The contrasting perspectives of men and women at Western's Engineering School are evident in the verbatim concerns about the difficulty of the engineering program before entry (the frequency of such concerns are equal within each gender—see Table 1).

Social issues and career-choice worries were mentioned by a few women and fewer men as being primary concerns before beginning the engineering course, but these concerns generally seemed to reduce in importance once the students were in the program. The exception was that more women than men were concerned about their choice of engineering as a career before entering the program, and this difference was increasingly marked in the first year. Such a result is similar to the finding that female freshmen are much less certain about their decision to major in science than their male counterparts, despite entering university equally confident and academically prepared [1]. Grover reports that women are more likely than men to pursue some other route before committing to engineering, rather than enter directly from high-school [3].

Table 1. Examples of external and internal orientation in concerns of first-year men and women Engineering students (emphasis added).

Men—externalization?	Women—internalization?
'... I've heard stories ... that *Western Engineering* is very difficult.'	'I was concerned that it might be too difficult for *me*.'
'Toughness of *program*.'	'My main concern ... was that *I* wouldn't be able to understand the material presented.'
'*It* would be too hard.'	'Whether *I* would be smart enough to become an engineer.'

Machismo and the gender ratio at UWO Engineering School

When questioned about the 'macho image' of some male engineering students, four of the twenty-two women, and one of the twenty-nine male respondents reported concern. Four other women said that they had been worried, but their experience in the first year had shown their fears to be unfounded. Five male students were uncertain as to their concern about 'macho' behaviour; hesitancy may indicate a lack of identification with the issue, or perhaps these men were uncomfortable verbalizing negative feelings about the once acceptable attitudes of some male peers.

The only question which did not appear on the male survey asked women if they were concerned that female students in engineering would be outnumbered approximately ten-to-one by male students. Of the twenty-two respondents, two reported that their concern prior to entry had now diminished, and one said she was, 'a bit [concerned] because in high-school most of my friends were girls'. Nearly 90% of the women did not feel the student gender ratio was a principal concern.

This is markedly different from the results of Grover, indicating 59% of women engineering students felt the gender breakdown at UWO was a problem [3]. However, most of Grover's respondents referred specifically to the underrepresentation of women among engineering faculty. The difference in question phrasing between the surveys should also be recognized: Grover asked whether the women felt the ratio was a problem, essentially 'in principle'; the question in this survey asked if the fraction of women students at UWO was of concern to the individual respondent.

When no distinction was made between student, staff, and faculty, American engineering freshmen gave responses similar to the results reported in this paper: about 70% of women indicated the proportions of males and females at their college were 'fine' [4]. Interestingly, about 60% of the American male engineering students considered there to be too high a proportion of men.

Social versus academic focus

Three questions directed women to answer with an exclusively female focus, while men were surveyed with no gender-focus specified. A sex-related pattern emerged, which had not been evident in the responses to questions phrased identically on both the male and female surveys: women students tended to refer to social or atmospheric aspects of UWO engineering more often than men, and male comments were more often on academic issues. It is not clear whether this trend represents women consciously ignoring what they perceive as 'unisex' academic considerations, or whether the female perspective in essence is more directed toward non-academic facets of the engineering program. The strength of the trend seems to be related to the placement of the question in the survey, perhaps because women grew accustomed to focusing on uniquely female viewpoints.

Early in the survey, for instance, students were asked if and why they would encourage a female/unspecified friend to apply for engineering at UWO. The majority of respondents agreed that they would, but while women cited social reasons only slightly less frequently than academic ones, the reasons given by male students for either encouragement or discouragement were predominantly related to perceived academic strengths or failings of the UWO engineering program.

About 30% of women students and 20% of men students were cautious about unconditionally advocating engineering at UWO. The women in this group emphasized the importance of a female candidate's perceived suitability for engineering with responses such as: 'If I thought they would be good at it and could handle engineering, I would encourage them, otherwise no!', '. . . as long as it is something she sincerely wants to do', 'Yes, if she has a vast understanding in math and sciences'.

While some men shared these views, they were just as likely to temper their encouragement of UWO engineering because they would more highly recommend engineering programs at other universities. This contrast would again support the hypothesis that women tend to internalize the determining factors for the outcome of their efforts: 'am I right for the program?' versus the male 'is the program right for me?'

Later in the survey, students were asked what alterations to the first year of engineering at UWO might make it more congenial to unspecified/female freshmen. The majority of men suggested changes to the academic program, primarily the reduction of academic pressures and the availability of personal work management aids such as tutorials, reviews, and exam writing strategies.

On the other hand, most women felt that no alterations should be made to improve the first year for females, either because it was already adequate or because such alterations would discriminate against their male peers. From the women who did suggest changes, proposals aimed to improve the atmosphere of the UWO Engineering School, as opposed to the academic program.

The results of this question, in particular, suggest a conscious exclusion by women students of academic issues. A general contradiction between engineering teaching styles and the preferred learning styles of the most male *and* female engineering students has been identified [10], and there is certainly no evidence from UWO engineering grades to suggest that, on average, women do not experience the same academic difficulties as men.

Surveyed students were then asked what improvements to recruiting might result in more female, or simply better, students entering UWO's Faculty of Engineering. Results are summarized in Fig. 4. 'Dispelling misconceptions' encompasses:

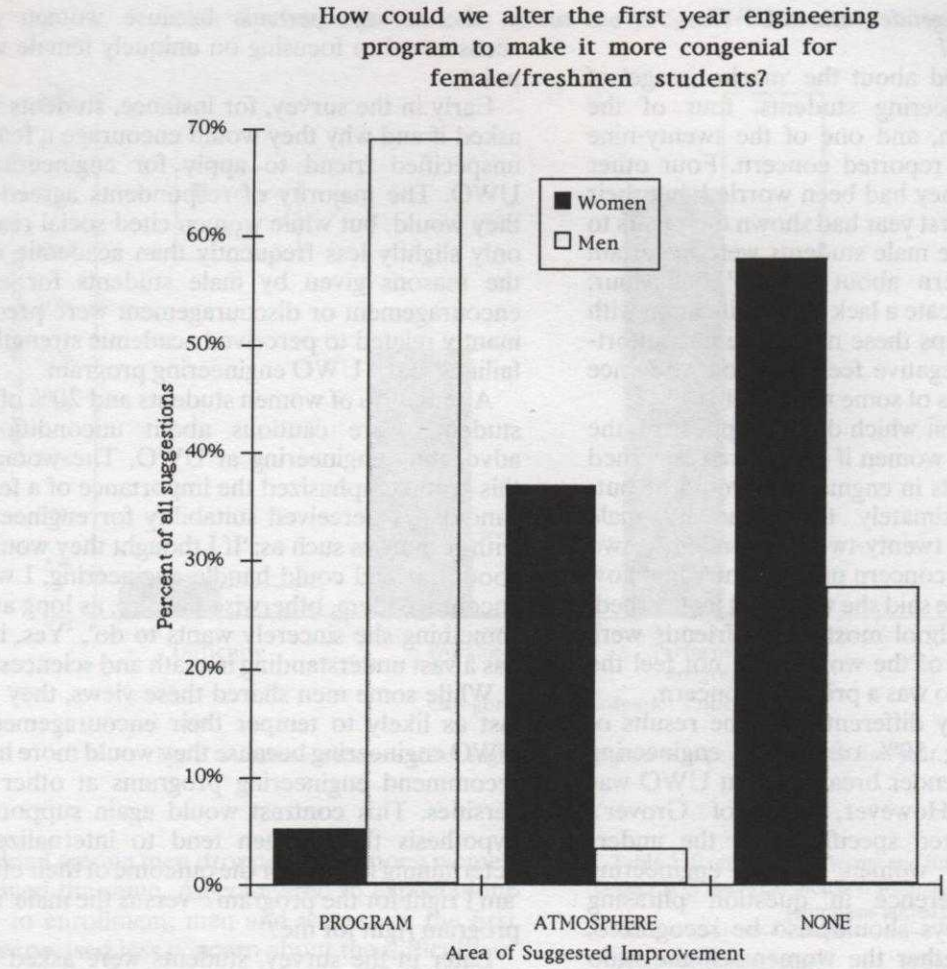

Fig. 3. Suggested alterations to make first year engineering more congenial for female (asked of women) and of unspecified (asked of men) students.

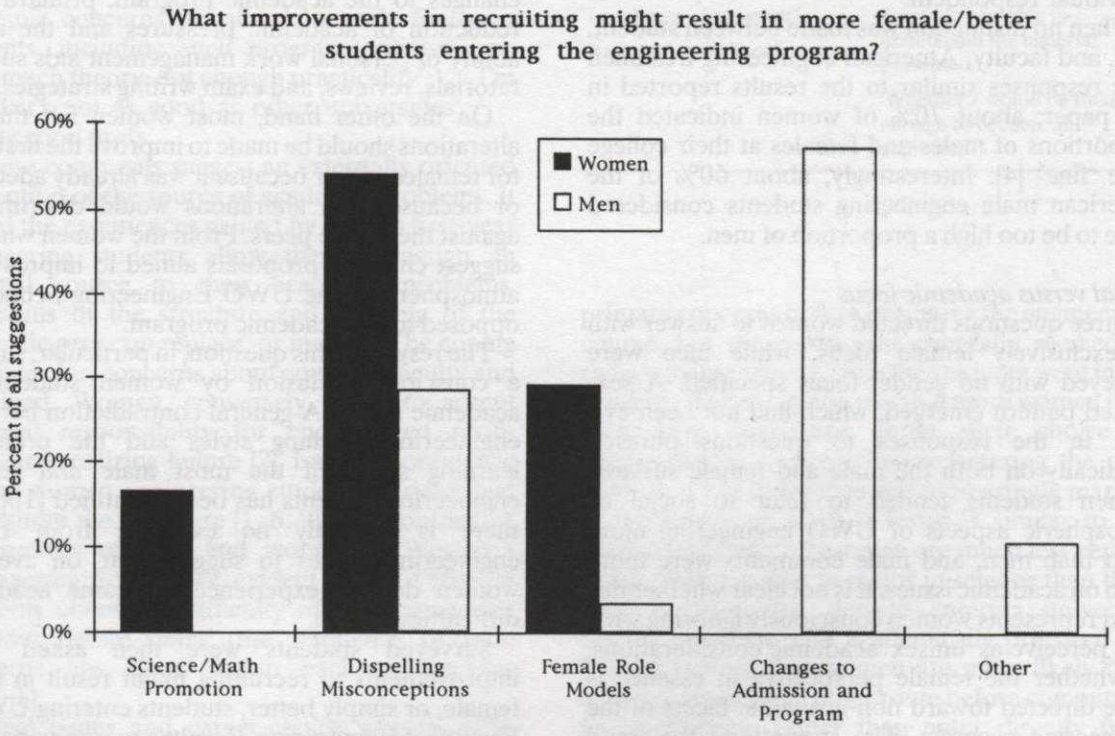

Fig. 4. Suggestions on how to recruit more female (from women) or better (from men) students to UWO Faculty of Engineering.

informing students more accurately about engineering programs and careers; educating high-school students and/or staff that engineering truly is an option for females (only mentioned by women respondents).

Grover obtained very similar responses when asking male and female engineering students at the University of Western Ontario to consider factors that might have increased their motivation for engineering, and asking women not in engineering what programmes might have encouraged them to consider entering engineering [3].

In particular, the importance placed by both men and women on providing a clearer picture of engineering is supported by many other researchers. In a survey by the Halifax School District Guidance Department, over half the women who did not choose to enter engineering lacked information about the field [2]—see also [7]. It has also been reported that, even among freshmen engineers, less than half of both men and women feel they understand the nature of an engineering career [4]. Both sexes of engineering students, as well as the women not in engineering, questioned by Grover ranked the lack of awareness of engineering as the main reason for the low number of women engineers [3].

In the preceding three questions, women were instructed to respond with an exclusively female focus, but men were given no such gender limitations. Comparing the answers of women and men in these cases may have overlooked the influence of gender specification on the women students' perspective. Directing a female focus in these three questions may also have affected the women's interpretation of later, gender-*unspecified*, questions, such as the last one in which all students were asked to express any other comments that might improve the UWO engineering environment: although not directed to do so, over half of the women who answered this question referred specifically to female issues. Once again, men were much more likely than women to criticize the academic program, as seen in Fig. 5.

It should also be recognized that specifying a female point of reference may have prompted some women students to downplay their concerns, either because they fear dissatisfaction will be interpreted as inability to cope, or just because they resent continual, albeit well-meaning, scrutiny:

> Don't make such a fuss about girls in engineering. Just accept it. I am actually getting tired of people telling me how great it is that I had the courage to be a 'female engineer'. It is not a big deal.

CONCLUSIONS

Men are more likely than women to enter Western's engineering program without positive encouragement. Within the Faculty of Engineering, overt issues of sexism, such as the 'macho image' of some male students and the small ratio of women to men enrolled, are of equally little concern to both genders of engineering students.

With respect to the other issues included in the survey, a female perspective on the engineering

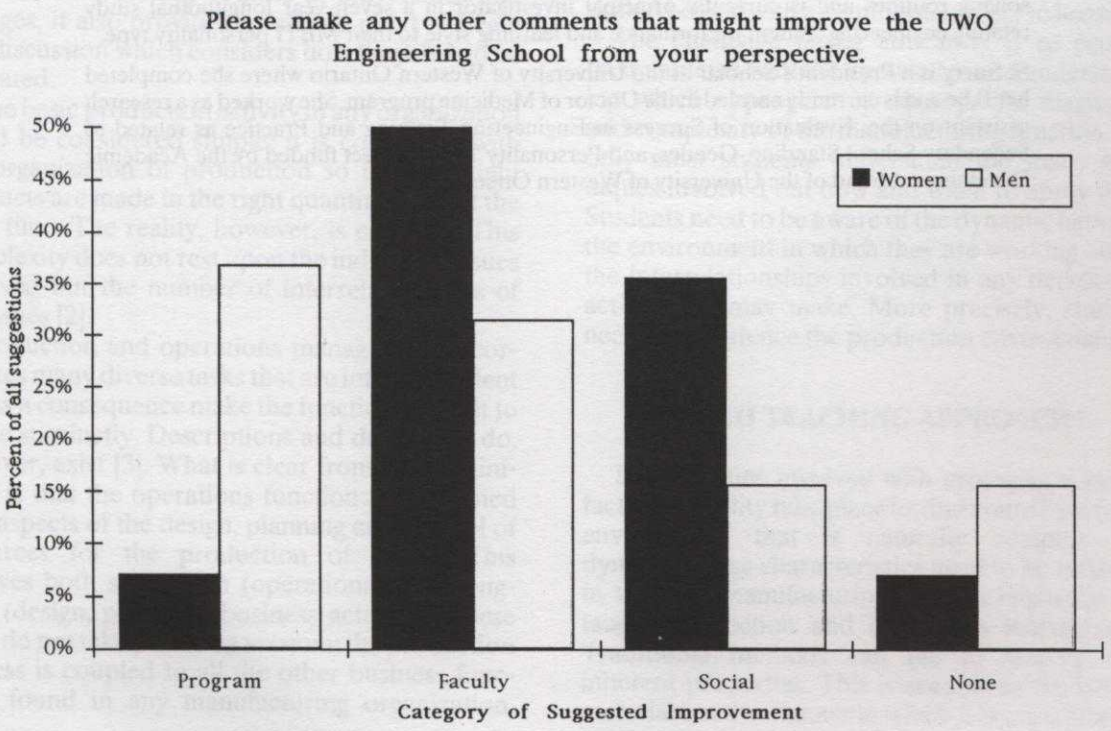

Fig. 5. Further proposals to improve the UWO Engineering School environment.

program at the University of Western Ontario emerges as distinct from the perspective of men students. Addressing the concerns of the male undergraduate majority, therefore, may specifically fail to benefit women as a group. The two main aspects which separate the approach and attitudes of women from men, as found in this survey of engineering undergraduates, are:

1. the perceived source of difficulties experienced—women tend to *internalize* a potential or existing problem's cause;
2. the facets of the engineering program felt to be of greatest importance—*non-academic* issues represent the most concerns to women, and hold the best potential for improving the program from their perspective.

REFERENCES

1. P. Rayman, A. A. Oberfield, and A. Amundsen, Women and science: no community support for a culture of success, *Women in Engineering Conference Proceedings*, pp. 37–45 (1991).
2. M. Frize (Chair), *More Than Just Numbers*, Report of the Canadian Committee on Women in Engineering, April (1992).
3. C. Grover, Women in Engineering with particular reference to the University of Western Ontario (Engineering Science 400 Project Report), University of Western Ontario (1990).
4. M. D. Ott, Sex differences in experiences and career plans of freshmen engineering students, *IEE Transactions on Education*, E-21(4), pp. 230–233, November (1978).
5. J. Z. Daniels, Women in Engineering: A Program Administrator's Perspective, *Engineering Education*, pp. 766–768, May (1988).
6. S. G. Brainard, Nuts and bolts of retention programs, *Women in Engineering Conference Proceedings*, pp. 215–220 (1990).
7. S. A. R. Garrod and M. R. Taber, Counseling Women in Engineering Technology to Prepare for Their Future, *ASEE Annual Conference Proceedings*, pp. 784–789 (1990).
8. N. B. Hellman, Retention of female students in Engineering, *Women in Engineering Conference Proceedings*, pp. 19–23 (1990).
9. E. M. Cooney, An Investigation of Gender Bias in EET Laboratories, *ASEE Frontiers in Education Conference*, pp. 257–261 (1991).
10. M. R. Anderson, Characterizations of the graduate career change women in engineering: recruitment and retention, *ASEE Conference Proceedings*, pp. 248–256 (1991).

Peter Rosati is a Professor in the Department of Civil Engineering at the University of Western Ontario (UWO). He has engineering degrees from Oxford and Western, and an education degree from West Virginia University. His research in engineering education has focused on problems associated with personalizing the large enrolment mechanics courses. He has implemented a successful Keller plan course in dynamics, investigated computer problem-solving routines and is currently principal investigator in a seven-year longitudinal study relating engineering student performance and learning style to their MBTI personality type.

S. Surry is a President's Scholar at the University of Western Ontario where she completed her B.Sc and is currently enroled in the Doctor of Medicine program. She worked as a research assistant on the 'Evaluation of Success in Engineering Training and Practice as related to Secondary School Standing, Gender, and Personality Type' project funded by the Academic Development Fund of the University of Western Ontario.