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# The Climate for Women in Science and Engineering: Perceptions of Canadian Graduate Students

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Abstract

A sample of 199 women and 188 men in Canadian science and engineering graduate programs responded to a survey, which investigated their departmental climate, opportunities for collaboration, social support, and feelings of inclusion. Analyses were conducted to identify differences between genders and differences between disciplines. The results showed gender-related differences for collaboration: women reported higher levels of collaboration between genders than men reported. Gender differences were also found between disciplines: women in engineering reported that their departments were less congenial to women and reported significantly lower person-discipline fit than did men in engineering. Within life sciences, men reported significantly higher levels of social support than did women.

## Introduction

Over the past thirty years, women in North America have made impressive gains in their representation in traditionally male-dominated occupations. Examples of this are law, medicine, psychology and management, where women now constitute 45% to 50% of students and a growing percentage of practising professionals.[1] There is little doubt however, that other science and engineering disciplines constitute notable exceptions to this trend. For example, although the number of women in engineering has increased significantly since the 1960s, the percentage of women receiving degrees in engineering is still low. In 2004 in Canada only 21.6% of undergraduate, 23.7% of Masters, and 15.5% of doctoral degrees in engineering were granted to women[2]. Moreover, only about 12% of faculty in engineering departments, and 12% of those employed as engineers in Canada were women[3]. U.S. figures are very similar[4]. In addition, research indicates that women who do become engineers are twice as likely as their male counterparts to abandon the profession after a few years in the workplace.[5] These figures suggest that the profession of engineering is having difficulty in both attracting and retaining women.

The failure of science and engineering programs to make themselves more attractive to women is troubling for several reasons. In the first place, it perpetuates occupational sex segregation. Secondly, given the increasingly significant role of technology in post-industrial societies, it means that women will continue to be largely excluded from powerful and central professions and the associated financial rewards and prestige. Lastly, and perhaps most importantly, science and engineering disciplines are failing to gain access to the skills and talents of half the population. In Canada, this will greatly exacerbate a forecasted serious shortage of scientists and engineers in the future.[6]

One reason for the failure to recruit and retain women in these professions could be the culture of the disciplines. Some have argued that, due to the past predominance of men in science and

engineering, the cultures in these disciplines are "masculine". [7,8,9,10,11] Concern has been raised that, because of this, graduate education in science and engineering is not conducive to women's values or learning needs.[12] Moreover, the attrition of women from science and engineering is frequently attributed to the presence of a "masculine" culture which results in a "chilly" climate. [9,13,14, 15]

According to Dryburgh[13] there has been little previous research on how women experience the cultures they encounter in science and engineering. Understanding the issues faced by women graduate students is particularly important because graduate school is a time of socialization into professional identity and of transition between student and professional roles.[14] Recently there have been a few studies on the experiences of women students in science and engineering, but the focus has been undergraduates[16,17] and graduate students at U.S. universities. [8,18,19] A better understanding of the factors that contribute to the under-representation of women in science and engineering programs in Canada can be useful to increase the number of women in these programs.

In order to better understand the climate in which women graduate students in science and engineering programs find themselves once they enter graduate school, the present research looked at the departmental climate, opportunities for collaboration, social support, and feelings of inclusion of men and women students in Canadian science and engineering graduate programs. The aim of the research was to understand the role climate has in the under-representation of women in science and engineering graduate programs in Canada.

## Method

Participants. The participants were 199 women and 188 men (plus 14 gender unidentified) graduate students enrolled in science and engineering programs across Canada. Respondents ranged in age from 22 to 54 years of age, with the majority being between 25 and 29 years of age. Fifty-six percent of participants were enrolled in a Master's program, 39% were enrolled in a Ph.D. program, and 5% did not indicate program type. The majority of participants were enrolled in engineering (37%) and life science programs (23%). There was a higher percentage of men than women in engineering programs and a higher percentage of women than men in life science programs. Eighty-five percent of the surveys were completed in English and 15% were completed in French. Fifty-nine percent of the participants listed English as their first language, 21% listed French as their first language, and 20% listed "Other" as their first language. Fifty-five percent of participants were single and 39% were married or living common law. Eleven percent of the participants had children living with them (27 men, 18 women) and 12% reported providing financial assistance to other family or relatives (36 men, 11 women).

Procedure. A link to the electronic survey was emailed to Deans/Department Heads of science and engineering programs across Canada, who were asked to forward it to graduate students in their departments. The survey was available to students in both French and English to ensure all students across Canada would be included.

Measures.

*Overall department climate*. Respondents were asked to rate the overall nature of their department climate using a scale taken from the University of Michigan Graduate Student Survey.[20]. The scale consisted of 14 bipolar adjectives: welcoming, friendly, racist, homogeneous, respectful, sexist, collaborative, cooperative, homophobic, supportive, flexible, protective, encouraging, and snobbish. The overall department climate score was composed of the average ratings of responses to the 14 adjectives. Scores ranged from 1 to 5 with higher scores representing a more positive climate.

*Congeniality of environment to women.* Perceived Congeniality of Environment to Women was assessed with a scale taken from Pascarella et al.[12] The score consisted of the average of the responses to eight statements regarding whether: 1) there is similar treatment of men and women; 2) prejudice or discrimination exists towards women; and 3) the course content reflects women's experiences. Scores ranged from *Strongly Disagree* (1) to *Strongly Agree* (5), with higher scores indicating a more positive (more congenial) environment.

*Collaboration between men and women.* Perceptions About Amount of Collaboration Between Men and Women were measured with a scale taken from Ferreira.[14] The score was composed of the average ratings of the responses to 13 statements that assessed students' perception of the interactions between men and women in their department (e.g., "In my department men students listen well to women," "I often discuss science/engineering with my male student colleagues"). Scores ranged from *Strongly Disagree* (1) to *Strongly Agree* (5), with higher scores indicating perceptions that there was greater collaboration between men and women.

*Person-discipline fit.* Perceived Person-Discipline Fit refers to the congruence between a person's values and those of their discipline. People prefer environments that match their values and fulfil their needs. Perceived Person-Discipline Fit was assessed by adapting a measure of Person-Organization Fit.[21] The Perceived Person-Discipline Fit score was composed of the average ratings of the responses to four statements that assessed students' perception of their fit with science and engineering programs (e.g., "My values 'match' or fit those of my graduate department," "My values 'match' or fit those of my research group/lab"). Scores ranged from *Strongly Disagree* (1) to *Strongly Agree* (5). Higher scores indicate a better perceived fit with the graduate program.

*Feelings of inclusion.* Feeling of Inclusion was assessed via the inclusion subscale of the Longitudinal Assessment of Engineering Self-Efficacy; Assessing Women in Engineering (LAESE).[22] Scores were the average of the responses to four statements (e.g., "I can relate to the people around me in my class," "The other students in my program share my personal interests"). Scores ranged from *Strongly Disagree* (1) to *Strongly Agree* (5), with a *Don't Know/ NA* option included. Higher scores indicate a higher perception of inclusion.

*Perceived social support.* Perceived Support was assessed with items taken from a measure by Williams.[23] Scores were composed of the average ratings of the responses to six statements. Four were from the social environment support subscale (e.g., "It is easy to make friends with other students") and two were from the program involvement support subscale (e.g., "I have

participated in a study group with other students"). Scores ranged from *Strongly Disagree* (1) to *Strongly Agree* (5), with a *Don't Know/ NA* option included. Higher scores indicate a higher perception of social support.

## Results

Climate and culture. With respect to the overall departmental culture, respondents rated their department climate fairly positively ($M = 3.88$, $SD = 0.63$). Comparisons were made between men and women graduate students with no significant differences being found, $t\ (384) = 1.55$, $p > .05$. However, a comparison of students in Ph.D. and Master's programs did result in a significant difference, $t\ (376) = 3.58$, $p < .01$. Respondents who were enrolled in Ph.D. programs ($M = 3.78$, $SD = 0.67$) perceived their overall program more negatively than respondents enrolled in Master's programs ($M = 3.97$, $SD = 0.58$).

Overall responses were again positive with respect to perceived congeniality of environment to women ($M = 4.03$). Similar views were held by women and men respondents, $t\ (380) = 0.17$, $p > .05$. Differences were found, however, between women and men engineering students. Women engineering students ($M = 3.92$, $SD = 0.56$) perceived their environment as being less congenial to women than men engineering students ($M = 4.15$, $SD = 0.49$), $t\ (140) = 2.48$, $p = .01$. An additional difference was found between Ph.D. students and Master's students. Respondents enrolled in Ph.D. programs ($M = 3.94$, $SD = 0.62$) perceived their environment to be less congenial to women than respondents enrolled in Master's programs ($M = 4.10$, $SD = 0.55$), $t\ (377) = 2.59$, $p < .01$.

On average respondents perceived a fairly high amount of collaboration between men and women in their departments ($M = 3.93$, $SD = 0.56$). A difference was found between women and men respondents. Women respondents ($M$=4.02, $SD = 0.54$) reported significantly more collaboration than men respondents ($M$=3.85, $SD = 0.56$), $t\ (381) = 2.98$, $p < .01$. An additional difference was found between respondents in engineering and life science. Respondents enrolled in life sciences ($M = 4.12$, $SD = 0.53$) reported significantly more collaboration between men and women than respondents enrolled in engineering ($M$ =3.82, $SD = 0.55$), $t\ (235) = 4.22$, $p < .001$.

Again average scores were moderate for person-discipline fit ($M = 3.50$, $SD = 0.77$), meaning respondents reported a moderate fit with their program. No significant differences were found between genders overall, $t\ (227) = 0.47$, $p > .05$. However, differences between genders were found for engineering students. Men engineering students ($M = 3.62$, $SD = 0.71$) reported a significantly greater person-discipline fit than women engineering students ($M = 3.35$, $SD = 0.80$), $t\ (135) = 2.10$, $p < .05$.

Feelings of inclusion. Average scores were moderate ($M = 3.46$, $SD = 0.81$), meaning respondents felt they somewhat included. No differences were found between the genders, $t\ (377) = 0.15$, $p > .05$. Differences were found, however, between disciplines. Respondents enrolled in the life sciences ($M = 3.66$, $SD = 0.84$) reported greater feelings of inclusion than did Engineering students ($M = 3.28$, $SD = 0.79$), $t\ (230) = 3.54$, $p < .001$.

Perceived social support. Overall social support was reported to be moderately high ($M$ = 3.68, $SD$ = 0.71). No significant differences were found between the genders overall, $t$ (383) = 0.75, $p$ = .45. A significant gender difference was, however, found between for students in the life sciences. Men respondents ($M$ = 4.01, $SD$ = 0.55) reported significantly higher levels of support than did women respondents ($M$ = 3.66, $SD$ = 0.76), $t$ (92) = 2.15, $p$ = .03.

## Discussion

The current study was an attempt to understand the role climate has in the under-representation of women in science and engineering graduate programs in Canada. In order to do this, graduate students in sciences and engineering were recruited from across Canada. Although the sample consisted of a relatively small percentage of the total population of graduate students in science and engineering in Canada, participants were drawn from students in a variety of subdisciplines in engineering, life sciences, math and computer sciences, physical sciences, and agricultural sciences. Furthermore, the sample had a good representation of Master's students and Ph.D. students. In addition, graduate students from all regions across Canada took part in the study.

Previous research had indicated that women graduate students in the U.S. were more likely to perceive their overall departmental climates[20] and the congeniality of those environments to women[12] more negatively than their men counterparts. We were, therefore, initially surprised to find few differences between the perceptions of men and women graduate students in this study. However, what this lack of differences appears to indicate is that men and women graduate students agree on the extent to which their department climates are inhospitable to women and to those from disenfranchised groups (e.g., racist, sexist, homophobic). What this does not imply is that men and women will be similarly affected by these climates. That is, men may be conscious of the fact that climates that are inhospitable to women and other under-represented groups exist in science and engineering, but as the predominant group, they may be immune from the negative effects of such climates.

The only overall gender difference that was found was in perceptions regarding the amount of collaboration that existed between men and women. Surprisingly, women perceived significantly more collaboration between the men and women in their departments than did men. This is likely due, however, to the higher concentration of women in the life sciences and in Master's programs where collaboration was perceived to be higher than in engineering or in Ph.D. programs. Other gender differences were found within disciplines. Within engineering, women reported that their departments were less congenial to women than men did. In addition, women in engineering reported significantly lower person-discipline fit than men. Within life sciences, men reported significantly higher levels of social support than did women.

Differences were also found between degree programs and between disciplines. Ph.D. students reported that their overall department climate was more negative and less congenial to women than Master's students. Furthermore, students in life sciences reported feeling more included than did students in engineering. When taken together, the picture that emerges is that wherever women are under-represented (e.g., in engineering vs. life sciences and in Ph.D. programs vs. Master's programs) the climates are more negative and less congenial to women, they feel less

included and more like they don't fit in, and they perceive a lower degree of collaboration between men and women.

The results of this study have a number of implications for science and engineering graduate departments. To begin, the fact that Ph.D. students perceived a more negative environment than did Master's students could negatively impact the decision of women to continue on to the Ph.D. degree once they have completed their Masters. As well, these perceptions may discourage women from seeking faculty positions when they graduate. With the aging baby boomer generation will come vacant faculty positions that will need to be filled. Ph,D. students who feel that their program is a negative environment are much less likely to apply for faculty positions than students who perceive a positive working environment. This suggests that efforts should be made to improve the working environment for Ph.D. students in order to retain them as qualified faculty in the future.

Findings from this study also have implications for the engineering field as a whole. Women engineering students found their environments to be less congenial to women and reported a lower person-discipline fit than their men counterparts. Clearly, such negative perceptions will impact future career choices and the ability of engineering faculties to recruit women.

There are several reasons why this study is important. First, it is the first to provide comprehensive information from men and women graduate students in science and engineering programs across Canada regarding their perceptions of their environments. As such, it provides up-to date data about the situations encountered by women graduate students in science and engineering. Second, it included a comparison group of men. From their data we were able to infer that men generally shared women's perceptions regarding the degree to which the graduate student climate was inhospitable to women and other under-represented groups, but that they sometimes did not experience the same negative effects of these climates (e.g., lack of social support, lower perception of fit with discipline) that women did. Third, the results of this study differed from data that had previously been collected from graduate students in the U.S. using the same measures[12, 20] indicating that one can not necessarily generalize findings across countries.

The results of this study differed as a function of the gender of the participant, their program and their degree type (with women, Ph.D. students, and those in engineering programs generally reporting more negative experiences). It should be noted, however, that overall the scores on all of the variables were moderate to high, with means of 3.5-4 on a 5 point scale. Thus, one can not conclude that graduate school experience for students in science and engineering in Canada is a negative one. Still, the results of this study lay the foundation for future research and point to specific areas where improvements could be made.

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