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Commitment to Graduate Studies and Careers in Science and Engineering: Examining Women's and Men's Experiences.

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ABSTRACT

A comprehensive survey was conducted to assess departmental, interpersonal and attitudinal variables related to Canadian student experiences in science and engineering graduate programs. The present study uses a subset of the survey variables to examine the experiences of women and men graduate students and to identify relationships between contextual factors and four specific outcomes: intention to leave current program, intention to pursue a career in field of study, science/engineering self-efficacy and confidence in establishing a career in one's field. Quantitative and qualitative results show that departmental climate and advisor support predicted student intentions, confidence and self-efficacy. Gender differences in self-efficacy and confidence were also found.

KEYWORDS

Gender; Engineering; Science; Graduate Studies; Department Climate; Self-Efficacy; Commitment.

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INTRODUCTION

As students and professionals, men in science and engineering far outnumber women in most countries around the world (UNESCO, 2006). Engineering and computer science tend to be the most male-dominated areas, whereas medicine and the life sciences are the least male-dominated (UNESCO, 2006). For example, in 2006 in the US, 20.1% of doctorates in engineering, manufacturing and processing; 21.6% of those in computing; and 49% of those in the life sciences were awarded to women, and in the UK the figures were 21%, 22.6% and 51.7%, respectively (European Commission, 2009).

The situation is similar in Canada. Despite progress in the participation of women at all levels of post-secondary education, women continue to comprise a minority in engineering and physical science disciplines, particularly at the doctoral level. In 2006-07, women earned 16.8% of doctorates in engineering, 23.7% of those awarded in computing and 34.4% of those awarded in physical sciences (Statistics Canada, 2009). Yet, available data do not tell the whole story. The diverse and complex experiences lived by women students in their specific environments are not captured by these recent statistics.

As a result of the historical predominance of men in science and engineering, the cultures within these disciplines have been characterized as 'masculine' (Fox 2001, 2003; McIllwee & Robinson, 1992; Rosser, 2002, 2004). In cultures characterized by 'masculine' norms, attitudes and values, there are fewer supports available for women who may experience feelings of social isolation and problems maintaining a positive sense of identity (Korabik, 1997). Negative experiences in graduate school related to inhospitable environments and lack of support, as Etzkowitz et al. (2000, p. 85) point out, 'result in the loss of many brilliant female minds to science and create damaged identities instead'. Seagram et al. (1998) found significant gender differences in the experiences of doctoral students (including social sciences, sciences and humanities). For example, women reported significantly lower levels of satisfaction with their advisors and advisory committees as compared to men. Self-efficacy has also been shown to be affected by the relationship with and support provided by one's advisor (Paglis et al., 2006; Shaeffers et al., 1997).

A study of two science departments, chemistry and biology, found significantly higher attrition rates of women graduate students as compared to men (Ferreira, 2003). In the chemistry department, the lack of collaboration, a competitive atmosphere and lack of advisor support were primary factors that contributed to women's decisions to leave. Although the biology department had a 'critical mass' of women, the perceived conflict between trying to balance a 'successful' career in science and a family appeared to be the main factor in the high attrition of women. Research has also shown that positive conditions for women's success in engineering

and science included standards of inclusivity, strong mentoring/advisor relationships, and institutional supports and policies (Handlesman et al., 2005).

Understanding the experiences of graduate students in engineering and science disciplines is particularly relevant to resolving the under-representation of women in these fields. Graduate school is a time of socialization into professional identity and of transition between student and professional roles (Sandler, 1986, as cited in Ferreira, 2003). Understanding the factors that contribute to, or undermine, professional identity and confidence can inform the development of programs and policies that enhance women's intention to stay in the program and to follow a career in science or engineering. While a lack of supervisor support can diminish persistence in science and engineering programs, the existence of personal and institutional support has been shown to buffer the effects of stressors and alleviate negative outcomes (Keita & Hurrell, 1994).

Previous research on the experiences of women students in science and engineering at U.S. universities has focused on undergraduates (Goodman et al., 2002; Margolis & Fisher, 2002) and graduate students (Fox 2003; Kuck, 2004; Xie & Shauman, 2003). To understand graduate student experiences and outcomes in a Canadian context, a comprehensive survey was developed to assess a wide range of departmental, interpersonal and attitudinal variables. The survey was administered to Canadian graduate students in science and engineering disciplines between November 2006 and June 2007 and preliminary results have been reported (Korabik, 2008; Korabik et al., 2008).

Using a subset of the survey variables, the aim of our present study was to characterize the experiences of women and the experiences of men in science and engineering graduate programs in relation to their commitment to the fields of science and engineering. Specifically, we examined the relationships between demographic and contextual factors and four outcomes: intention to leave current program; intention to pursue a career in field of study; self-efficacy in science and engineering; and, confidence in establishing a career in one's field of study. To build understanding of the ways in which women and men experience the cultures within Canadian graduate programs in science and engineering, we included measures of departmental climate, congeniality of the environment towards women and the degree of collaboration between men and women. We also incorporated measures of perceived support from advisors and perceived social support from other students in the program. In addition, we analysed women's and men's responses to open-ended survey questions that asked about feelings of discouragement, students' intention to leave their program, as well as sources of motivation and encouragement to continue in the program.

METHODS

The Canadian survey tool was available in French and English formats through separate web links. It was advertised widely through a number of networks including Deans, Department Chairs and Graduate Coordinators for science and engineering programs across Canada as well as the five regional NSERC Chairs for Women in Science. Contacts were asked to encourage graduate students in their departments and institutions to participate. There was telephone follow-up with

some network contacts to ensure representation from across Canada. Survey responses were collected between November 2006 and June 2007. The survey included both quantitative and qualitative measures.

Quantitative Measures

Quantitative items were rated on 5-point Likert-type scales. Reliability of these scales was assessed using Cronbach's measure of internal consistency.

Departmental climate.

A scale to assess climate within a department was taken from the University of Michigan survey of doctoral students (Malley et al., 2006). The scale consisted of 14 pairs of bipolar adjectives. Participants rated the extent to which they perceived each adjective pair characterized their department. For example, adjective pairs included: *welcoming -unwelcoming; respectful - disrespectful; non-sexist - sexist; collaborative - individualistic; and, supportive - not supportive*. The overall score for department climate was composed of the mean ratings of the 14 pairs. Higher scores represented a more positive climate. Reliability was $\alpha=.85$.

Congeniality of environment to women.

Perceived congeniality of environment to women was measured using a scale from Pascarella et al. (1997). The scale was based on agreement with statements regarding equal treatment of men and women; prejudice or discrimination towards women; and inclusiveness of course content in terms of women's experiences. The score was calculated as the overall mean of responses to eight items. Higher scores indicate a more congenial environment. Reliability for the scale items was $\alpha=.80$.

Degree of collaboration between men and women.

Degree of perceived collaboration between men and women (Ferreira, 2003) was composed of the mean ratings on 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*"). Higher scores indicate a perception of greater collaboration between men and women. Reliability was $\alpha=.91$.

Advisor support.

A scale from the University of Michigan survey of doctoral students (Malley et al., 2006) was adapted to assess graduate students' relationship with their primary advisor. Items included in this scale are related to perceptions of support for research and career aspirations, availability, and advisor-student interactions (e.g. "*My primary advisor helps me secure funding for my graduate studies*"; "*My primary advisor is available to me when I need help with my research*"; "*My primary advisor treats my ideas with respect*"). The score for Advisor Support was calculated as the overall mean for 17 scale items. Higher scores indicate more positive advisor support. Reliability was $\alpha=.91$.

Perceived social support.

Six items from Williams' (2002) scale of perceived social support were used. Four items were used from the social environment support subscale (e.g., "*It is easy to make friends with other students*") and two from the program involvement support subscale (e.g., "*I have participated in a study group with other students*"). Scores reflect the mean of these six items, with higher scores indicating a greater perception of social support. Reliability was $\alpha=.77$.

Self-efficacy.

Science/engineering self-efficacy was measured by adapting items from the Longitudinal Assessment of Engineering Self-Efficacy (Assessing Women in Engineering, 2005). Participants were asked to indicate their agreement with 14 statements related to their ability to succeed in their field. Items included "*I can complete any science/engineering degree at this institution*", "*I can excel in a science/engineering degree during the next year*", and "*I can succeed in a science/engineering curriculum while not have to give up participation in my outside interests*". Reliability for this measure was at $\alpha=.78$.

Intention to leave the program.

Five items were created to assess participants' intention for quitting graduate school or changing their program of study. These items included "*I think about quitting my graduate studies*" and "*I intend to apply to a different graduate program*". Reliability for this measure was $\alpha=.82$.

Intention to pursue a career in science/engineering.

A single item was included to assess participants' intention of continuing into a career related to their field of study. The item asked "*Given the opportunity, how likely are you to pursue a career in science or engineering*". Response options ranged from "*Almost certainly I won't*" to "*Definitely I will*".

Confidence in obtaining a career.

Confidence in obtaining a career in one's field of study was measured using a scale from the University of Michigan survey of doctoral students. This scale asked participants to assess their confidence on a number of statements related to pursuits after they finish their degree. They were asked to indicate their confidence irrespective of whether or not they actually intended on pursuing a particular career path. Items included "*I have the skills to become a professor at a top research university*", "*I have the skills to obtain a research job in industry or the private sector*", and "*I have the skills to be successful in my field*". Reliability was $\alpha=.87$.

Demographic variables included in our analyses were discipline (engineering, physical and computer sciences, and life sciences), degree level (Master's, PhD), student gender and advisor gender. Life science programs included biology, biochemistry, biomedical, environmental science, food science and nutrition. Physical science programs included chemistry, earth/atmosphere and physics programs, along with computer science and mathematics.

Qualitative Measures

We evaluated responses to open-ended survey questions that asked about feelings of discouragement, students' intention to leave their program, as well as sources of motivation and encouragement in their program. French language responses were translated into English and included in our analysis. Categories were developed according to dominant themes in participant responses and congruence with established understanding of specific constructs (e.g. self-efficacy, mentoring and social support, advisor support). Participant responses were then coded according to these categories. A second rater coded 25% of the qualitative data and Cohen's kappa (K) was used to assess inter-rater reliability. Inter-rater reliability was good to very good for each of the categories, ranging from $K=0.77$ to $K=1.0$.

Analysis

We conducted statistical analyses using SPSS 16.0 software. First, we conducted a Multivariate Analysis of Variance (MANOVA) to explore between group differences across the contextual variables and second, a hierarchical regression analysis to examine the relationships between the demographic and contextual variables and the four outcome variables.

We conducted the MANOVA first to answer whether there were differences in student perception of department climate that were related to demographic variables. Specifically, we wanted to examine whether women and men graduate students had different experiences and whether there were any effects of advisor gender on student perceptions. As well, we were interested to know whether student perception differed between male-dominated (engineering and physical and computer sciences) and more gender-balanced disciplines (life sciences). The independent variables in the MANOVA were discipline, degree level, student gender and advisor gender, giving us a 3x2x2x2 factorial design. The dependent variables in the MANOVA were climate; congeniality of environment to women; degree of collaboration between men and women; advisor support; and, perceived social support.

We then conducted hierarchical regression analysis to examine whether the contextual variables (departmental climate, congeniality of environment to women, collaboration between men and women, advisor support and perceived social support) could predict the outcome variables beyond what could be predicted by demographic differences. Demographic variables (discipline, degree level, student gender and advisor gender) were entered in the first block of the regression analysis as dummy variables - that is, each category within a variable (e.g. male or female; engineering, physical and computer science or life science) was assigned a numerical code to indicate membership or non-membership within that category. The five contextual variables were then entered in a second block. Four regression analyses were conducted using the outcome variables of self-efficacy; intention to leave the program; intention to pursue a career in science/engineering; and, confidence in obtaining a career as the dependent variables.

We analysed the qualitative data according to the frequency of responses. As well, we used chi-square analysis to identify significant differences in the frequency of responses across student gender and program.

RESULTS

There were 401 science and engineering students across Canada who completed the survey. Excluding those who did not indicate their gender or discipline, 363 participants were included in our analyses. Table 1 shows the number of men and women students by discipline and degree level. Overall the sample is balanced by gender (183 men and 180 women). There were 212 Master's students and 151 doctoral students in the sample. Across disciplines, 145 were in engineering programs, 98 were in life sciences programs and 120 were in physical and computer science/math programs. Not unexpectedly, the sample is comprised of significantly fewer women in the engineering and physical/computer sciences programs than in the life science programs, $\chi^2(2)=21.55, p<.001$. Significantly more women than men students report having women advisors, $\chi^2(2)=8.01, p<.01$. Table 2 shows the number of women and men participants with female and male advisors.

Table 1. Participants by gender, discipline and degree level.

| | Degree Level | |
|--------------------------------|--------------|-----|
| | Master's | PhD |
| Engineering | | |
| Female | 43 | 17 |
| Male | 45 | 40 |
| Physical and Computer Sciences | | |
| Female | 33 | 19 |
| Male | 37 | 31 |
| Life Sciences | | |
| Female | 38 | 30 |
| Male | 16 | 14 |

Table 2. Participants by student gender and advisor gender.

| Advisor Gender | Student Gender | |
|----------------|----------------|--------|
| | Male | Female |
| Male | 156 | 131 |
| Female | 27 | 48 |

Overall participants perceived the climate of their departments as moderately positive ($M=3.89, SD=.63$). They rated congeniality of the environment to women positively ($M=4.04, SD=.57$) and perceived a moderate degree of collaboration between men and women ($M=3.95, SD=.82$). Mean ratings of perceived social support ($M=3.68, SD=.71$) and advisor support ($M=3.70, SD=.68$) were also moderately positive. On the outcome variables, participants reported high self-efficacy ($M=4.17, SD=.47$) and fairly high confidence in obtaining a career ($M=3.79, SD=.52$). Intention to pursue a career in science or engineering was also high ($M=4.29, SD=1.01$) and consistent with low intention to leave ($M=1.64, SD=.73$).

Multivariate Analysis of Variance

There was a significant main effect of degree level on both climate and congeniality of the environment to women. Doctoral-level participants ($M=3.78$, $SD=.68$) characterized their department climate more negatively than Master's-level participants ($M=3.98$, $SD=.57$), $F(1, 341)=7.82$, $p<.01$). As well, doctoral-level participants ($M=3.94$, $SD=.62$) rated congeniality of environment to women significantly lower than Master's-level students ($M=4.13$, $SD=.51$), $F(1,349) = 11.93$, $p<.01$.

For degree of collaboration between men and women, there was a significant main effect of discipline, $F(2,341)=4.13$, $p<.01$. After the Bonferroni correction for post-hoc comparisons was applied, engineering students ($M=3.82$, $SD=.55$) reported significantly lower collaboration between men and women than life sciences students ($M=4.09$, $SD=.53$).

Hierarchical Regression Analysis

Demographic variables.

The demographic variables as a group were not significant predictors of the outcome measures. Discipline, as an individual variable, was a significant predictor of intention to pursue a career in one's field ($\beta=.31$, $t(348)= 2.44$, $p<.05$). Engineering students ($M=4.48$, $SD=1.04$) had greater intentions to pursue a career in their field than those in the science disciplines ($M=4.16$, $SD= 1.13$) Discipline was also a significant predictor of self-efficacy, ($\beta=.20$, $t(349)=-2.98$, $p<.01$). Being in engineering ($M=4.25$, $SD=.40$) predicted higher self-efficacy than being in life sciences ($M=4.02$, $SD=.53$). Student gender was a significant predictor of confidence in obtaining a career in one's field ($\beta= -.12$, $t(350)= -2.18$, $p<.01$). Women students ($M=3.72$, $SD=.55$) had lower confidence scores than men students ($M=3.85$, $SD=.48$).

Contextual Variables.

Table 3 shows the zero-order correlations between the contextual variables in the second block of the hierarchical regression analyses and the four outcome variables: self-efficacy; confidence in obtaining a career in one's field of study; intention to leave; and, intention to pursue a career in science or engineering.

Table 3. Zero-Order Correlations Between Contextual and Outcome Variables

| | Climate | Congeniality of Environment to Women | Collaboration Between Men and Women | Advisor Support | Perceived Social Support |
|--|---------|--------------------------------------|-------------------------------------|-----------------|--------------------------|
| Self-efficacy | .28** | .24** | .24** | .34** | .30** |
| Confidence in obtaining a career in field of study | .25** | .18** | .25** | .42** | .32** |
| Intention to leave | -.37** | -.31** | -.25** | -.47** | -.18** |
| Intention to pursue career | .14** | .15** | .04 | .20** | .13* |

*Correlation is significant at $p < .05$

**Correlation is significant at $p < .01$

The second block in the hierarchical regression analysis, which included the contextual variables, was significant across each of the outcome variables. Advisor support was a significant predictor of the four outcome variables. Perceived social support was a significant predictor of science/engineering self-efficacy and confidence in obtaining a career in one's field. Department climate was a significant predictor of intention to leave and collaboration between men and women was a significant predictor of confidence in obtaining a career. Congeniality of the environment to women did not significantly predict any of the outcome variables.

For science/engineering self-efficacy, the second block was significant ($\Delta F(5, 340)=16.90, p<.001$) and explained 19% of the variance in self-efficacy scores. Advisor support ($\beta=.21, t(349)=3.93, p<.001$) and perceived support ($\beta=.18, t(349)=3.07, p<.01$) were the significant predictors among the contextual variables. Higher scores on advisor support and perceived social support predicted higher self-efficacy scores. Both variables were significantly correlated with self-efficacy at the zero order level (Table 3). The semi-partial correlations indicated that advisor support accounted for 4% of the unique variance in self-efficacy and perceived social support accounted for 2% of the unique variance in self-efficacy.

For confidence in obtaining a career, the second block of context-related variables was significant, ($\Delta F(5, 341)=24.36, p<.001$), accounting for 26% of the variance. Degree of collaboration between men and women ($\beta=.15, t(350)=2.66, p<.01$), advisor support ($\beta=.33, t(350)=6.14, p<.001$) and perceived support ($\beta=.22, t(350)=3.92, p<.05$) were significant predictors of confidence in obtaining a career. Higher scores on these contextual variables predicted higher scores on confidence in obtaining a career in one's field. The semi-partial correlations indicated that degree of collaboration between men and women accounted for 1%, advisor support for 8%, and perceived support for 3% of the unique variance in confidence in obtaining a career scores.

For the intention to leave outcome measure, the second block of variables was significant ($\Delta F(5,342)=24.98, p<.001$) and explained 26% of the variance in scores. Poorer departmental climate ($\beta=-.15, t(351)=-2.45, p<.05$) and less advisor support ($\beta=-.35, t(351)=-6.59, p<.001$) were significant predictors of higher intention to leave. The semi-partial correlations indicated that climate accounted for 1% and advisor support accounted for 9% of the unique variance in intention to leave.

Because the zero-order correlations between only four of the contextual variables (departmental climate, congeniality of the environment towards women, advisor support and social support) and intention to pursue a career in science or engineering were significant, only these four were entered into the second block in this analysis. This block was significant ($\Delta F(4,339)=5.17, p<.01$), explaining 8% of the variance in intention to pursue a career in science or engineering scores. Advisor support ($\beta=.22, t(351)=2.43, p<.05$) was the significant predictor of this intent, with a semi-partial correlation indicating that it accounted for 2% of the unique variance in intention to pursue a career in science or engineering scores.

Qualitative Findings

In our analysis of participants' open-ended responses, we focused on sources of discouragement, sources of motivation and encouragement, and on intentions to leave one's program. There were two hundred and ninety-five participants (149 women and 146 men) who responded to at least one of the open-ended questions included in our analysis.

Half of the sample reported feeling some sense of discouragement in their program of study, with some explicitly recognizing that this experience was a normal and regular part of being a graduate student. There was a significant difference across disciplines with fewer engineering students reporting having ever felt discouraged ($\chi^2(2)=6.69, p<.05$). Sources of discouragement were similar for all the disciplines. Most predominantly, women and men across all disciplines reported feeling discouraged with the progress of their research. Self-doubt and lack of confidence in one's abilities along with uncertainty about the applicability of one's degree also regularly emerged as sources of discouragement. A male student described his feelings of self-doubts as "*Bursts of the 'imposter' syndrome - not feeling that I am capable of competing in the academic world*" and a female student described her concern over the value of her graduate studies as "*the work we do in school is very removed from the real working world.*" These sentiments characterized the experience of both women and men in our sample. Men and women also similarly wondered whether they had the capability to finish their degree and whether their degree would provide them with the career opportunities they desired. There was no significant difference as a function of gender in the frequency of reported feelings of discouragement. Yet in looking more closely at participants' reasons for feeling discouraged, more subtle gender differences emerged.

Although only a small number of graduate students (1%) invoked discrimination as a reason for feeling discouraged in their programs, all of these responses were made by women. Their experiences related to having been subjected to poor treatment or comments that disparaged women, such as *"discriminatory comments from instructor about being female."* Women also identified challenges or exclusions related to other ways in which one may be marginalized: *"There seems a glass window on top of the head to curb your growth because of language, culture, gender"* and *"the percentage of GLBTQ students in science/engineering is never discussed, it is a taboo topic in my dept. - it is not a welcoming/open/accepting environment."*

Women more often voiced the fear that they lacked the necessary experience or skills to succeed in their degree or future career. Of those who described feelings of discouragement, 15% of women compared to 5% of men described feelings of self-doubt and uncertainty about their abilities or about being in the right field and career path. These women said: *"I have felt 'stupid' or 'incompetent' especially during my first year - I found the transition from undergrad to grad difficult at times"; "I'm not sure I possess all the qualities needed in a research scientist"; and "I wonder if ... I have the skills to get a job in the field I am interested in."* This uncertainty was seen to carry over to thoughts about leaving their program.

Women more frequently attributed their thoughts about leaving their program to the field that they were in, citing loss of interest or speculating that they would be better suited to a different area of study. One of these women said: *"I am thinking of changing because I believe that I have chosen the wrong field. I am scared of not succeeding."* Another reported that she was considering leaving her field because *"[I] realize to get promoted in science/engineering field/companies is harder for women. So [the] idea comes out to change to another field like business."* Or more directly, *"I just think I might not be cut out for this."*

We wish to emphasize however, that this difference in the expression of self-doubt does not occur within a context where women generally lacked confidence. Rather, on average, women in our sample expressed a fairly positive sense of confidence and self-efficacy. Where feelings of uncertainty and self-doubt did emerge, they were slightly more likely to be expressed by women and if expressed by women, to be related to intentions to leave the program.

Both men and women graduate students in our sample mentioned the challenges of maintaining work-life balance, particularly managing the demands of graduate work with those of being a good partner and parent. However, these concerns appeared to be stronger for the women in our sample. Women more often mentioned the strain that resulted from attempting to balance multiple roles (11% of women compared to 3% of men who reported feelings of discouragement). In trying to balance her studies and her relationship, one woman reported that she *"Felt guilty with the amount of time I was working, eventually ended in a divorce."* Women were more direct in expressing their concerns over the possibility of combining a family and an academic career. A few thought having children as a graduate student or as a future

faculty member would be a potential disadvantage to them. One woman said: "*[I] feel stressed that ... pursuing a tenured faculty position would be difficult if I have children in the future*". Only women cited the pressures on family life as a reason for thinking about leaving their program. One woman described these pressures as: "*I've thought about quitting my graduate studies because the workload does not allow me spend time with my family and relax. I feel overworked and stressed often and guilty for not being able to give the people I love the time that I would like to.*"

There were significant gender differences with regard to factors that were perceived to contribute to one's academic success. Significantly more women than men in our sample cited support from family and friends as a factor that helped them succeed in their departments ($\chi^2(1)=4.98, p<.05$). One woman characterized this support as "*Support from family and friends in dealing with obstacles and stress presented in the course of studies.*" As well, significantly more women than men attributed their continuance in their program in part to the supportive atmosphere within their labs and amongst other graduate students ($\chi^2(1)=5.75, p<.05$) - "*The other students are friendly and helpful, the atmosphere is one of facilitation rather than competition.*" Common to both men and women were attributions of success due to personal motivation, hard work and determination.

The relationship with one's advisor was the most frequent reason for feelings of discouragement, intentions to leave, and sense of success for both genders and across all disciplines. Responses made it clear that an advisor's capacity for listening to, showing interest in, understanding and encouraging his or her graduate students contributed to their motivation and commitment to graduate studies. Characteristic responses by women and men satisfied with their advisors included: "*He is an incredible teacher and treats me like an equal rather than as a subordinate. He's very smart and helpful*"; "*He's always available to help. He ensures I stay on track with my research and deadlines. He encourages and helps me with publications*"; and "*She is always available if I have problems and is ready to discuss things over.*" The provision of helpful advice and direction for the student's research was valued as were advisors who were perceived to be open and engaging when discussing student ideas and interests. Conversely, advisors who were perceived to be unsupportive or disinterested were sources of discouragement and contributed to intentions to leave the program. Characteristic responses by men and women dissatisfied with their advisor included: "*He is never available and after 3 terms I still don't have a topic*"; "*Throughout my graduate program he has been condescending and has taken my confidence away. His ideals are different than mine and he doesn't encourage me to pursue things that are related to my future objectives, but instead pushes me to do things he would pursue*"; and "*Lack of interest in my research/education, no direction/guidance for my project.*" The majority of women and men in our sample reported having a positive relationship with their advisor.

DISCUSSION

Student outcomes related to the likelihood of continuing in their field of study were fairly positive. There was a low intention to leave one's program coupled with a high intention to pursue a career in one's field of study. As well, there was fairly high

confidence for obtaining a career in one's field of study. Support from one's advisor was the most consistent predictor of positive outcomes on these variables. Higher collaboration between men and women and perceived support from other students were also related to higher confidence in obtaining a career in one's field. By contrast, a poor departmental climate significantly predicted a greater intention to leave one's program.

We anticipated greater gender differences than we found. Overall there were no significant differences in women's and men's perception of the department climate, congeniality of the environment towards women or degree of collaboration between men and women. However, the mean ratings for all of these variables were only moderately positive. Both men and women doctoral students perceived that climate was less congenial to women than students at the master's level did. This is a concern since it undoubtedly affects women's motivations to pursue academic careers. The few women who did note a discriminatory environment or an environment inhospitable to balancing the demands of academic and family life also paired these experiences with feelings of discouragement and thoughts of leaving or not pursuing a career in their field.

The gender difference that did arise was in science/engineering self-efficacy. Women graduate students reported significantly lower self-efficacy and confidence than did men. Generally lower self-efficacy in women relative to men is a consistent finding across a number of areas of science and technology, beginning at a young age (Else-Quest et al., 2010; Vekiri & Chronaki, 2008) and persisting through advanced education levels (Davidson et al., 2008; Watt, 2006; Zeldin & Pajares, 2000). It should be strongly noted, however, that women's science/engineering self-efficacy was low only in relation to the men in our sample; their self-efficacy was not low in an absolute sense.

The results from the qualitative data provided further insight into these findings. In participant responses, significant, as well as more subtle, gender differences became apparent. For women, sources of discouragement and thoughts about leaving their program of study were more often related to feelings of uncertainty and apprehension about their skills. The challenges of balancing academic or professional pursuits with family life also seemed to be a greater barrier for women than for men. These feelings and experiences may in part contribute to their lower sense of confidence in obtaining a career in one's field of study. Recognising these gender differences, the Chairs for Women in Science and Engineeringⁱⁱ offer a number of workshops at local, regional and national levels to provide opportunities for women in graduate and post-doctoral programs to discuss their experiences and share strategies as well as to interact with successful role models.

Consistent with the quantitative analysis, our analysis of the qualitative responses also showed that for both women and men graduate students, advisor support was a predominant influence on student experience. The influence of the relationship and interactions with an advisor on feelings of motivation or discouragement, commitment or ambivalence to the program was strongly reflected in the relay of

their experiences. This finding is consistent with the extensive literature on mentoring (e.g. Handelsman et al. 2005; Stewart, 2006). What we did not find were gender differences in the perception of degree of advisor support or in the qualitative evaluation of the advisor relationship. A small number of women did express a sense of disadvantage or discrimination in working with their men advisors, yet the great majority of women with men advisors did not raise any concerns or identify the gender of their advisor as a relevant attribute. Furthermore, our analyses of the contextual and outcome variables did not reveal any disadvantage to cross-gender student-advisor dyads.

CONCLUSION

To our knowledge this is the first survey of Canadian graduate students to assess departmental climate and interpersonal factors on intention to leave and commitment to careers in science and engineering. Publicly available statistics on attrition rates in graduate programs in science and engineering at Canadian universities are limited. However, based on a collaborative study by a group of large Canadian institutions, doctoral graduation rates for physical and applied sciences were reported to be about 80% (Berkowitz, 2003). Unfortunately there was no gender-based analysis in the report but it does suggest a significant loss of talented women and men.

The Canadian survey was comprehensive in terms of the number of institutions, geographical reach and coverage of science and engineering disciplines yet we recognize that the total number of respondents was low and that we cannot assume that it was a representative sample. The response rate was disappointing but we acknowledge that the time required to complete the survey was significant (about 1 hour) and it required a considerable commitment to participate in the study. The survey length reflected our interest in developing a comprehensive understanding of department climate, inter-personal and personal experiences during graduate studies. However we recognize that some groups of respondents (e.g. those with significant family responsibilities) may not have had time to participate. Furthermore there was no way to contact students who had dropped out of their program or those on leave. Future research should address ways to engage a diverse pool of graduate students.

We also recognize the limitation in our reliance on a cross-sectional design and use of self-reported measures of intention to leave one's field of study and intention to pursue a career in one's field. It is possible that while one may report a low intention to leave or high intention to pursue a career in one's field of study, circumstances and events may intervene to disrupt the realization of these intentions. More longitudinal research that follows women through their undergraduate and graduate programs to their post-graduate career decisions would provide further insight into the reasons for the attrition in women in the science and engineering fields. The regional Chairs for Women in Science and Engineering are collaborating on two initiatives: a survey of career transitions for students in engineering and computer science and equity indicators for recruitment and retention of faculty in science and engineering faculties in Canada (Smit Quosai et al., 2009)

Departmental climate and advisor support did emerge in the quantitative and qualitative analysis as important factors in predicting student intentions, confidence and self-efficacy for both women and men graduate students in science and engineering disciplines. The perception of a supportive atmosphere within the department contributed to perceived success in one's program. Advisor support and a satisfactory advisor relationship were also strongly related to more positive intentions, greater confidence and self-efficacy. A lack of support and more negative relationships with one's advisors were sources of discouragement and contributed to intentions to leave the program.

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ENDNOTES

ⁱ Gay, Lesbian, Bisexual, Transsexual, Queer

ⁱⁱ The Natural Sciences and Engineering Research Council (NSERC) supports one Chair for Women in Science and Engineering (CWSE) in five geographic regions across Canada. The mandate of the CWSE program is broad with objectives to address the need to encourage, inspire, support and ultimately, retain more women as students and professionals in science and engineering. Each Chair is a role model and she continues to be active in university teaching and research during the 5 year term. The Chairs are also focal points for thinking about the challenges for increasing the participation of women in science and engineering and acting more broadly.

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