Influence of Role Models and Mentors On Female Graduate Students' Choice of Science as a Career

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A thesis submitted to the Department of Education

in partial fulfillment

of the requirements for the degree of

Master of Arts in Education

August, 2005

Your file Votre référence
ISBN: 978-0-494-17508-8
Our file Notre référence
ISBN: 978-0-494-17508-8

ABSTRACT

The purpose of the present study was to examine the source, nature, and degree of influence that role models/mentors have had on female graduate students' choice of science as a career. Also explored was the question of whether the influence of role models/mentors differed between male and female science graduate students in general and within the biological and physical sciences. A related purpose of this study was to test the validity and reliability of the adapted version of the Influence of Others on Academic and Career Decisions Scale (IOACDS, Nauta & Kokaly, 2001) on a graduate student population. The results of the factor analysis on the IOACDS adapted version corroborated Nauta's finding that role models and mentors are two distinct entities that influence students in distinctly different ways. Significant gender, area of study, and undergraduate country differences were found on the adapted version of the IOACDS as well as for the types of role models/mentors identified.

ACKNOWLEDGMENT

I am grateful to my thesis supervisor, Dr Anne MacCleave, for her patience and guidance throughout this process. I am appreciative of the help and suggestions of my thesis committee, Dr Jeff Young and Dr Rosemarie Sampson. I acknowledge the assistance of the staff and the participation of the students of Mount Saint Vincent University and Dalhousie University in this study.

On a personal note, I thank my parents, Anna and Laszlo Fried, for their constant love and support. Finally, thank you to my own role models and mentors, Dorothy and Yair Reznick.

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CHAPTER ONE

Introduction

The under representation of women in science, technology, engineering, and mathematics (STEM) careers in North America is a problem that has been researched extensively over the past thirty years. Although women have increased their representation in several professional fields in recent decades, they remain very much a minority among professionals employed in STEM careers. In Canada, for example, women made up almost half of all doctors and dentists (47%), almost half of all professionals employed in business and finance (49%), and more than half of all professionals employed in social sciences and religion (58%) in 1999. However, women represented only 20% of professionals in the natural sciences, engineering, and mathematics in 1999 (Statistics Canada, 2000). In the United States, the numbers are similar, with women constituting 23% of the science and technology labor force in 1997 (National Science Foundation, 2000).

Furthermore, it is unlikely that female representation in these occupations will increase in the near future because women continue to account for relatively small shares of total university enrolment in these fields (Statistics Canada, 2000). For example, in Canada between 1997 and 1998, women made up more than half (56%) of all students in Bachelor's and first professional degree programs. However, women represented only 29% of all math and physical science students and only 22% of all engineering and applied science students. Similarly, in the United States between 1997 and 1998, women made up more than half (55%) of all students enrolled in undergraduate degrees in general but only 19% of those enrolled in engineering. These proportions are reflected at the doctoral level as well. For example, in Canada between

1997 and 1998, women made up well over half of full-time doctoral candidates in both education (66%) and fine and applied arts (59%) as well as approximately half in the social sciences (52%) and the humanities (50%). In contrast, women made up 40% of doctoral candidates in agricultural and biological sciences, 23% in mathematics and physical sciences, and only 16 % in engineering and applied science. Similarly, in the United States between 1997 and 1998, women made up almost three quarters of graduate students in psychology (71%), and approximately half in social sciences (49%) and biological sciences (50%). In contrast, women made up fewer than 20% of graduate students enrolled in engineering.

The Problem with Women's Under Representation in STEM Careers

Why, one might ask, is it even a problem that women are under represented in STEM careers if they are more than well represented in other careers? According to Williams & Emerson (2002), as minorities in the STEM professions, women are often inadvertently subject to marginalization, which manifests itself in various subtle and not so subtle ways. The most documented of these occur in the areas of financial and professional advancement.

Financially, whatever their educational attainment, women's earnings in the STEM professions are lower than those of their male counterparts. For example, in Canada in 1997, the earnings ratio for females and males employed full-time, full year, was just over 80% among professional employed in the natural sciences (Statistics Canada, 2000). Similarly, in the United States in 1997, the overall median salary for full-time female scientists was approximately 81% of the overall median salaries of male scientists (National Science Foundation, 2000).

Professionally, women in the STEM professions continually miss out on or have reduced opportunities for advancement within their field despite having research records equivalent to their male counterparts. Several studies have shown that women in science and technology receive lower salaries, lower status, and poorer prospects of promotion than men (in Acker & Oatley, 1993: Brush, 1991; Frieze & Hanusa, 1984; Matyas, 1985; Morrell, 1991; and Scott, 1990). More recently, a study by Wenneras and Wold (1997) revealed that women scientists received smaller grants than men with equivalent research records. As well, in a study conducted at the Massachusetts Institute of Technology (MIT, 1999), it was found that women faculty had lower salaries, less lab space, and smaller grants than men with equivalent records.

According to Williams and Emerson (2002), women will only be able to combat these various forms of marginalization and significantly influence the culture and norms of the scientific institutions in which they work once they have reached a critical mass (i.e., that women comprise at least one-third of all employees in the organization). In order for this to occur, women need to be encouraged to pursue careers in the STEM professions. This would not only benefit women, who would be afforded a wider choice of career paths and greater financial independence, but this would benefit the scientific institutions who hired them, as they would gain access to a larger, more diverse, talent pool, which would ultimately lead to increased organizational productivity.

Factors that Contribute to Women's Under Representation in STEM Careers

In order to find solutions to the problem of under representation of women in the STEM professions, one must first identify the possible reasons for the problem. According to Betz (1994):

> There are three critical points in the "pipeline" at which women are lost to the sciences: first, the initial choice of career in the sciences, engineering, and mathematics; second, the transition from undergraduate degrees in the sciences, where women are considerably better represented than at the graduate level, to the pursuit and attainment of Master's and, especially, PhD degrees; and third, hostile "climates" for token women in academe and elsewhere, which may reduce occupational success and satisfaction, and, in some, case, may lead to abandonment of her career. (p. 238)

Large bodies of research exist on the reasons why women do not initially choose STEM careers and why those who do, do not persist in their careers. However, considerably less research exists on why women who initially choose to pursue STEM careers during their undergraduate studies do not persist in their pursuit by continuing their studies at the graduate level.

Institutional Climate and Support

According to Betz (1994), since women entering graduate programs are as well prepared academically as men, one has to look at the institutional climate and lack of social support to explain the losses of women for graduate programs in science and engineering. The institutional climate may be particularly inhospitable to women because of the overt and subtle forms of discrimination that can take place. Some of the overt forms of discrimination include: higher admissions requirements for female than male applicants; sex quotas for admission; discrimination in the award of financial aid; and sexual harassment. More subtle forms of discrimination include: disparaging women's intellectual abilities; ridiculing or trivializing their questions in class; ignoring their attempts to participate; advising them to lower their academic and career goals; responding with surprise when they express demanding career goals; not actively encouraging them to apply for fellowships, grants, and awards; and focusing on marital and parental status as a potential barrier to career development. Various studies report on the hostile institutional climates faced by women pursuing STEM studies at the graduate level: the discomfort of being in a minority (in Acker & Oatley, 1993: Thomas, 1990); lesser likelihood of being accepted as a serious colleague (in Acker & Oatley, 1993: Matyas, 1985; Taylorson, 1984); fewer opportunities for funding and research experience (in Acker & Oatley, 1993: Matyas, 1985); sexist humour and language; textbooks that omit women's contributions (in Acker & Oatley, 1993: Morrell, 1991); negative judgements and beliefs about female graduate students' commitment to and qualifications for the study of computer science (MIT, 1983).

Mentors

Lack of social support, in the form of mentors, is another important factor that Betz identifies as a possible reason for women not persisting in their pursuit of STEM careers at the graduate level. Betz argues that because most science and engineering professors are male and are more comfortable and accustomed to male students, they are more likely to choose, whether consciously or not, to be mentors to male rather than female graduate students. This view is supported by research that suggests that mentors choose protégés with whom they identify and identification is likely to depend on gender, race, and social class (Shapiro et al, 1978). The lack of mentors for women graduate students can lead to exclusion from informal and discretionary interactions. Discretionary approaches from a faculty member include inviting the students to work on his or her research, either voluntarily or as a paid research assistant, to coauthor a paper, and to present together at a scientific meeting. Informal interactions include having lunch together, participating in sports, and being introduced by him or her to colleagues attending conventions. In one study (MIT, 1983), female graduate students in computer science reported that not being able to participate in informal interactions, that facilitated both research collaboration and future potential interactions, was one of the most serious barriers to their success as scientists. In another study (Zappert & Stansbury, 1984), female graduate students in science and engineering at Stanford reported experiencing difficulty convincing faculty members, who were mostly male, to become their mentors and maintaining a close working relationship with their mentors, once they succeeded in finding one.

Role Models

Lack of social support, in the form of female role models, has also been identified as a possible reason for women not persisting in their pursuit of STEM careers at the graduate level. According to Ehrhart and Sandler (1987), being the "token" woman, makes a woman feel that she does not belong, which can impede behavior and undermine self-confidence. Tokens may often feel that their performance will reflect poorly on their entire sex or race. The resulting anxiety and perfectionism can be debilitating to performance. For women or minority group members in science and engineering, the most important ingredient becomes the presence of other women or minority students and faculty. When critical mass is reached, there are sufficient opportunities for social support, and the feeling that "they are in the same boat" can encourage a woman or minority person to persist. Whether career support comes in the form of mentors or role models is there a theoretical basis for a lack of social support influencing academic and career choice?

Theoretical Basis of Social Support as a Career Influence

Various theoretical frameworks have been developed and adapted over the past thirty years to explain how our social environment may influence our behaviours, including academic and career decisions (Bandura 1969, 1977, 1982, 1986). Bandura's Social Learning Theory proposed that our self-efficacy expectations (i.e., our beliefs about our own competence with respect to specific domains of behaviour) determine whether we choose to engage in a particular behavior, the effort that we expend on an activity, how well we perform, and whether we persist in the behavior when faced with obstacles. Self-efficacy expectations are initially developed and subsequently modified by four sources of efficacy information: performance accomplishments (i.e., experiences of successfully performing the given behavior); vicarious learning or modeling (observing others successfully performing the behavior); freedom from anxiety with respect to the behavior; and verbal persuasion and support from others.

Among others, Lent, Brown, and Hackett (1994) extended Bandura's theoretical concepts to the study of career development. Hackett and Betz (1981) proposed a theoretical framework, based on the Bandura's Social Learning Theory (1969), that specifically addressed the issue of how social support, or lack thereof, may lead to women's under representation in male dominated career areas. They suggested that the observation of relevant and successful role models may increase a person's self-efficacy expectations with respect to many traditionally male-dominated career fields, particularly those in the sciences and technology. Nauta et al (1998) proposed that self-efficacy was mediated by both role model influences and role conflict; that is; role models demonstrate how potential role conflicts can be negotiated or handled.

In summary, Bandura's social-cognitive theory highlighted what self-efficacy was and how it influenced our behaviours. Additionally, Bandura's work also foreshadowed the distinction between role modeling and mentoring. Although the focus of the research has been on the pathway from a role model influence to a learner's self-efficacy to career choice, an important factor that mediates self-efficacy has been overlooked. Not only does vicarious learning or modeling (i.e., role model influence) influence self-efficacy expectations but verbal persuasion and support from others (i.e., mentor influence) also influences these expectations, which, in turn, influences career and academic decisions.

Empirical Research on Social Support as a Career Influence

Empirical research has documented the influence of social support, in the form of role models and mentors, on academic/career choice and persistence in general. Studies on the influence of role models/mentors on academic choice and persistence demonstrated that role model supportiveness and relationship quality contributed to career decidedness of male and female college students (Perrone, Zanardelli, Worthington, & Chartrand, 2002). Mentor support also predicted career commitment of male and female doctoral students (Ulku-Steiner et al, 2000). Students who observed a successful role model in a specific occupational field were more likely to believe that they themselves would be successful in the field and to express a preference for entering that career (Scherer et al, 1991; Little & Roach, 1974). In addition, college students' perceived role model influences related to career salience, level of educational aspirations, non-traditionality of occupational choices, and college major choices (Hackett et al, 1989). Pre-and post-doctoral productivity among scientists was found to be related to collaboration with a mentor (Reskin, 1979)

Studies on the influence of role models/mentors on career choice and persistence have demonstrated that mentoring has positive long-term effects on career outcome, job satisfaction, organizational socialization, and income (Chao, 1997). Mentors were perceived as crucial tools for training and promoting career success by both males and females (Hunt & Michael, 1983). Having a mentor was associated with increased job satisfaction, higher salary, faster promotion, firmer career plans, and increased probability that the protégé would also become a mentor (Missirian, 1982; Roche, 1979). In studies of successful women, mentorship has been cited as a critical factor in their success (Missirian, 1982; Phillips, 1977).

Empirical research has also documented the influence of role models/mentors on academic/career choice and persistence in the sciences and non-traditional careers. Studies on the influence of role models/mentors on academic choice and persistence in the sciences and non-traditional careers demonstrated that female university students viewed role models as especially important in choice and persistence in nontraditional fields (Gilbert, 1985). A study of male and female first year career undecided college students demonstrated that math/science career interest increased after viewing a video of graduates of university who were successful in a science/math career (Luzzo et al, 1999). Studies also showed that exposure to role models through television or written materials increases students' likelihood of considering non-traditional careers (Greene et al, 1982; Saveyne, 1992).

Studies on the influence of role models/mentors on career choice and persistence in the sciences and non-traditional careers demonstrated that positive role model influence was associated with lower anticipated role-conflict among women pursuing non-traditional careers (Nauta et al, 1998). In addition, women who had been exposed to role models who successfully combined career and family responsibilities were more likely to believe that combining work and family demands can be accomplished effectively (Almquist & Angrist, 1971).

Although these studies demonstrate that role model/mentor influences are related to academic/career choice and persistence, most have not explored the specific ways in which this influence occurs. One of the reasons for this omission may be related to the fact that few of these studies actually differentiate between the terms "role model" and "mentor". Without clear operational definitions of the two, outlining the specific characteristics of each, it is difficult to determine the specific ways in which their influence occurs. Therefore, before continuing any further discussion of the specific influences that role models/ mentors may have on academic/career choices, it is important to provide detailed definitions of the terms "role model" and "mentor".

Definition of Role Models and Mentors

Various definitions of role models exist in the literature: "someone whose life and activities influenced the respondent in specific life situations" (Basow & Howe, 1980, p.559); "adults who are worthy of imitation in some area of life" (Pleiss & Feldusen, 1995, p.163); and "real or theoretical persons perceived as being ideal standards for emulation in one or a selected number of roles" (American Psychological Association, 1982, p.150).

Various definitions of mentors exist in the literature as well. However, the one provided by Wright and Wright (1987) is all encompassing. According to Wright and Wright, mentors are veteran professionals who take an active interest in the career development of younger professionals. Mentors usually encourage and support the career aspirations of their protégés, provide opportunities for their protégés to observe and participate in their work, and help their protégés become aware of the unwritten rules and politics involved in the profession. Hildreth (2002) claimed that the related "mentorship" term is synonymous with terms such as teaching, training, enlightening, guiding, interpreting, informing, advising, educating, and nurturing.

It would appear, therefore, from these definitions that the primary defining characteristics of role models and mentors is that role models are people who, by being admirable in one or more ways, have an impact on another while mentors are people who, by exerting some influence, have an impact on another.

Nauta and Kokaly (2001) suggest that another reason that specific role model/mentor influences have not been explored is that a multidimensional role model influence scale did not previously exist. According to Nauta and Kokaly (2001), The Influence of Role Model Scale (IRMS; Basow & Howe, 1975) is limited because it only assessed the respondent's perceived positivity or negativity of influence from various role models (e.g., mother, father, siblings, teachers, etc.) on the respondent's life in general as opposed to influence specifically related to academic and career decision-making. In addition, the IRMS only assesses influence from role models the respondents know personally, thus not allowing for the possibility that students may be influenced by role models they know only through the media or through historical accounts. The Career Influence Inventory (CII; Fisher & Stafford, 1999) does assess the influence of certain people (e.g., parents, peers, and teachers) on students' career behaviors but still does not examine the specific ways in which those 'influencers' impact on career outcomes. In addition, it too does not allow for the assessment of the influences of role models not necessarily known personally by the respondent.

In an attempt to examine more thoroughly the dimensions of role model influence relevant to young adults' academic/career decisions, Nauta and Kokaly (2001) developed a measure of role model influence on students' academic and career decision-making processes called the Influence of Others on Academic and Career Decisions Scale (IOACDS). The scale was developed in a series of stages. In the first stage, undergraduate students were asked, through open-ended questions, to identify the role model (e.g., family member, peer, teacher/advisor/coach, famous person/character, other) who had the most influence on their academic and career decisions and how that person had influenced them in their decision. Students' responses to the latter question were then grouped into five categories (1) Gives advice (2) Encourages/supports, (3) Inspires, (4) Models, (5) Helps make decisions. When categorizing student responses, Nauta and Kokaly also noted that many of the students' statements reflected types of influence that would not necessarily be associated with role models (e.g., providing emotional support), but rather would be associated with "supportive others". For example, their statements reflected perceptions of emotional support, reassurance, and unconditional acceptance. Thus, it appeared that students' perceptions of influence from others they had nominated as academic/career role models extended beyond the traditional definitions (e.g., APA, 1982; Pleiss & Feldhusen, 1995) of role models, which emphasize imitation and emulation. Instead, students in this study included active support in their perception of role model influence.

In the second stage of scale development, a 35-item pool for the IOACDS was generated (seven items for each of the five categories of influence) which was then administered to a different group of undergraduates. Factor analyses revealed two distinct factors. One factor was named the Support/Guidance factor while the other was named the Inspiration/Modeling factor. The results of their analysis lent support to the idea that mentoring/role modeling influences had, at least, two distinct dimensions. Although Nauta and Kokaly do not suggest that providing support and guidance should be included as a defining characteristic of role models, these results suggest that the importance of recognizing that persons perceived as role models may be able to facilitate academic and career development via their support and guidance as a well as via the degree to which they provide inspiration and modeling.

Purpose of the Study

Research conducted by Nauta and Kokaly (2001) lent strong support to the notion that role modeling and mentoring were distinctly different influences. This work also developed and validated the IOACDS, an instrument used to assess these influences. The IOACDS was validated with a group of undergraduates across various disciplines. Will this instrument differentiate role modeling from mentoring for graduate science students?

Given the scarcity of female role models in STEM careers, it would be important to discover whether and to what extent role modeling and mentoring influenced academic and career decisions. If mentoring were found to be influential, steps could be taken within programs to increase this form of support.

The purpose of the present study was to examine the source, nature, and degree of influence that role models/mentors have had on female graduate students' choice of science as a career. Also explored was the question of whether the influence of role models/mentors differs between male and female science graduate students in general and within the biological and physical sciences. A related purpose of this study was to test the validity and reliability of the adapted version of the Influence of Others on Academic and Career Decisions Scale (Nauta & Kokaly, 2001) on a graduate student population.

Research Questions

The following research questions were formulated to guide this study:

1. What are the psychometric properties of the adapted version of the IOACDS with this sample of graduate science students?

2. a Are there differences in factor scores on the IOACDS (adapted version) between male and female science graduate students?

   b. Are there differences in factor scores on the IOACDS (adapted version) between graduate students in different areas of study (i.e., biological sciences, physical sciences, and engineering)?

3. a. Are there differences in the types of role models and mentors identified as

having been the most influential in career decisions between male and female science graduate students?

b. Are there differences in the types of role models and mentors identified as having been the most influential in career decisions between graduate students in different areas of study (i.e., biological science, physical science, and engineering)?

CHAPTER TWO

In this section, details about the selection of the participants and development of the surveys are shared. Also addressed is a summary of the statistical analyses and procedures.

Participants

The participants were graduate students in the science programs of Dalhousie University in Halifax, Nova Scotia. Dalhousie was selected in particular because it has the greatest number and largest variety of graduate programs in the region. The participants for this study were male and female graduate students pursuing Masters or Doctoral degrees in 21 programs in the areas of engineering, physical science and biological science. Table 1 lists the male, female, and total enrollment in the 21 programs in 2003 (list provided by the office of the Dean of Graduate Studies, Dalhousie University).

Although the focus of this study was on the influence of others on female graduate students' choice of careers in the areas of engineering and physical sciences, the decision was made to include male graduate students and graduate students in the biological sciences for the purpose of comparison. A comparison group helped to discern whether the influence of others differed in any way for female engineering and physical sciences graduate students.

Table 1

Dalhousie University Science Graduate Student Enrolment

PROGRAM	FEMALE	MALE	TOTAL
MA Computer Science	23	69	92
MASC Engineering			
Biological	1	1	2
Biomed.	11	7	18
Chem.	3	8	11
Civil	7	21	28
Electrical	4	50	54
Industrial	2	5	7
Mechanical	3	16	19
Master of Engineering			
Civil	1	4	5
Electrical	1	8	9
Internetworking	10	83	93
Mechanical	1	1	2
Petroleum	2	5	7
PhD Engineering			
Biological	5	5	10
Chem.	1	7	8
Civil	1	17	18
Electrical and Computer	2	14	16
Industrial	3	2	5
MSc Math	3	7	10
PhD Math	2	4	6
MSc Stats	2	5	7
PhD Stats	4	1	5
MSc Physical Sciences			
Chem	15	16	31
Physics	4	10	14
Earth Sciences	4	8	12
Oceanography	10	9	19
Engineering Math	2	8	10
PhD Physical Sciences			
Chem	13	25	38
Physics	3	14	17
Earth Sciences	7	9	16
Oceanography	5	15	20
Engineering Math	0	5	5
MSc Biological Sciences			
Biochemistry	12	5	17
Biology	29	13	42
Microbiol.& Immunology	14	4	18
Physiology & Biophysics	5	3	8
Anatomy and Neurobiology	2	9	11
PhD Biological Sciences			
Biochemistry	6	9	15
Biology	30	34	64
Microbiol.& Immunology	7	8	15
Physiology & Biophysics	4	5	9
Anatomy and Neurobiology	3	5	8

Instrumentation

The materials for the study consist of an information letter (Appendix A) and a survey (Appendix B) and. The survey is comprised of three parts:

1) An adapted version of the Influence of Others on Academic and Career Decisions Scale (IOACDS, Nauta & Kokaly, 2001); 2) Questions eliciting background information (e.g., graduate students' gender, age, name of degree program, level and year of graduate program); and 3) Questions eliciting career choice information (e.g., what is their chosen career, when did they choose their career, who, if anyone, influenced their choice and to what extent).

Influence of Others on Academic and Career Decisions Scale

This survey instrument was selected because it is content relevant and the validation of the instrument is very thorough. The IOACDS was developed in order to assess the degree and type of role model influences on the academic and vocational decisions of undergraduate students. The 15 item scale consists of two subscales: the Support/Guidance subscale and the Inspiration/Modeling subscale. The Support/Guidance subscale consists of seven positively worded items (e.g., There is someone who helps me consider my academic and career options.) and one negatively worded item (e.g., There is no one who shows me how to get where I am going with my education or career.). The inspiration/modeling subscale consist of four positively worded items (e.g., There is someone I am trying to be like in my academic or career pursuits) and three negatively worded items (e.g., There is no one I am trying to be like in my academic or career pursuits). The IOACDS is scored using a 5-point Likert scale (1=Strongly agree and 5= Strongly disagree). Reverse scoring is used for negatively worded items.

The scale was developed through a two-stage process. In the first stage, survey items were generated in order to ensure relevant content. A diverse group of 116 undergraduate students from a large midwestern university in the United States were asked to indicate which role model in each of five categories (family members; teachers, advisors, coaches; famous people/characters; others) had the most influence on their academic and career decisions. Students were also asked to indicate how that person had influenced them in their decision. Students' responses to the latter were then grouped into five categories (inter-rater agreement kappa = .64): (1) Gives advice (2) Encourages/supports, (3) Inspires, (4)Models, (5) Helps make decisions. An initial 35-item pool for the IOACDS was generated (seven items for each of the five categories of influence) with each item consisting of a statement to which respondents indicated agreement or disagreement on a 5-point Likert scale (1=Strongly agree and 5= Strongly disagree).

In the second stage, the psychometric properties of the initial IOACDS item pool were assessed and items were selected for the final scale. A diverse group of 190 undergraduate students from a large mid western university in the United States were asked (different from the ones who had participated in the first study) were asked to complete the initial 35-item IOACDS. The students' responses were then used to conduct an exploratory factor analysis, using principal-axis method and oblique rotation. A two factor solution resulted: Factor I (Support/Guidance) accounted for 34% of the variance among items after rotation while Factor II (Inspiration/Modeling) accounted for

26% of the variance. For the final version of the IOACDS, eight items with the highest loadings for Factor I and seven items with the highest loadings for Factor II were retained. The remaining items were discarded owing to ambiguous loadings. The coefficients alpha for Factor I and Factor II were .90 and .89, respectively. The coefficient alpha for the total scale was .91.

Test-retest reliability and internal consistency estimates were high. The Pearson product-moment test-retest correlation coefficients between scores on test and retest for the Support/Guidance, Inspiration/Modeling, and total scales were .71, .78, and .80, ps <.001, respectively, suggesting that the scale measured a construct that is relatively stable over a 10 week period.

Measures of concurrent validity were also taken. Support/Guidance and Inspiration/Modeling subscales correlated significantly with measures of general social support (Social Provisions Scale; Cutrona & Russell, 1987), occupational information (My Vocational Situation; Holland, Daiger, & Power, 1980), career certainty and indecision (Career Decision Scale; Osipow, et al, 1976). No significant correlations were found when the IOACDS was compared to a measure of social desirability (Marlowe - Crowne Social Desirability Scale; Crowne & Marlowe, 1960), suggesting that social desirability was not a biasing factor. Only the Inspiration/Modeling subscale was significantly related to a measure of vocational identity (My Vocational Situation; Holland, Daiger, & Power, 1980.)

For the purpose of the present study, which is to assess the degree and type of role model influences on graduate students' academic and vocational decisions, the scale was adapted so that the statements were changed from present to past tense (e.g., There was someone who helped me to consider my academic and career options.). Statements containing “academic or career” were changed to “academic/career” in order to facilitate comprehension. As well, the values (i.e., 5 became “Strongly agree” and 1 became “Strongly disagree”) and the order of the numbers (i.e., the numbers were rearranged from 1 2 3 4 5 to 5 4 3 2 1.) in the 5-point Likert scale of the IOACDS were modified so that higher numbers equaled greater strength of agreement. The 15 items of the IOACDS were randomly selected for positioning in the current version of the scale.

Career Choice Information Questions

The Career Choice Information section of the survey is comprised of general questions pertaining to participants’ career choices (i.e., whether they had decided on their choice of career; what their chosen career was; and when they had decided on their career choice). As well, more specific questions are posed about what male and/or female role models and/or mentors within the university setting in particular had influenced their choice of career (i.e., academic advisors, undergraduate professors, graduate professors, or others) and to what degree (using a 5-point Likert scale: 5=encouraged me greatly, 4=encouraged me, 3=did not encourage or discourage me, 2=discouraged me, 5=discouraged me greatly). These descriptors acknowledge that mentors and role models may have a negative as a well as a positive influence.

Ethical Considerations

Third Party Permission

Once ethical approval has been granted by the MSVU Ethics Review Committee, the Dean of Graduate Studies at Dalhousie University read the ethics review application form and provided written confirmation that Dalhousie granted the researcher permission to conduct the study.

Risks

There were no foreseeable risks to the participants.

Informed Consent

Although formal written consent was not required for this study, all participants were asked to give informed consent. The Information Letter that the participants received (Appendix 1) indicated that by completing and returning the survey, the participant had agreed to participate in the study. Information provided by participants was confidential and no deception was employed in the collection of data

Privacy, Confidentiality, and Anonymity

Participants were asked in the Information Letter to remain anonymous and to abstain from writing their names anywhere on the survey. The surveys were numbered for the sake of data entry. Only aggregate data was reported in the thesis or any subsequent publication. Once data entry was completed, the surveys were stored in a locked cabinet in Dr. Anne MacCleave's office. They will be kept there until the study/thesis has been completed and defended, after which they will be destroyed via paper shredding.

Dissemination of Results

An executive summary of the results will be mailed to the Dean of Graduate Studies at Dalhousie University and the graduate coordinators of the graduate programs involved in the study. The graduate coordinators will be asked to make the results of the study available to the students who received the surveys.

Procedure

Once ethical approval was granted, the researcher conducted a pilot of the revised version of the IOACDS on a sample of 17 graduate education students enrolled in a Research Literacy course (GEDU 6170) at Mount Saint Vincent University. The purpose of the pre-test was to establish the content validity of the questions in the survey and to determine the average amount of time it took to complete the survey. The researcher verbally informed the students of the purpose of the study and explained that completion of the survey was voluntary and that confidentiality would be maintained by having the students complete the surveys anonymously. The researcher then instructed the participants to write down, on the survey, the amount of time it took them to complete the survey and any comments about the survey once they had completed it. Most of the students completed the survey in 5-10 minutes. Although the students found the Background and Career Information sections (Sections 2 and 3 respectively) to be self-explanatory, they had more difficulty understanding the IOACDS-adapted version (Section 1). Many students found the questions to be confusing because they seemed to be repetitive by asking the same question in different ways (i.e., There was someone who supported me in the academic/career choices I made. / There was no one who supported me in my academic/career decisions).

Although the students had found the Background and Career Information sections to be self-explanatory, the decision was made to revise these sections in order to make them more focused on the university environment as this was the area in which results could most inform university practice. Once these revisions were made, the final version of the survey was sent to the Dean of Sciences at Dalhousie University for third party approval. Once third party approval was granted, the researcher contacted the department heads, coordinators, and professors of the 21 science departments selected for the study. In the span of approximately one month (March 25 – April 18, 2003), the researcher distributed the surveys to the graduate students of the various departments either by attending seminars or by mailbox distribution.

Data Analysis

The sample was described by calculating frequency counts and percentages of the demographic data. In order to determine differences between the groups (i.e., between male and female biological science and computer science, engineering, mathematics, statistics, physical science graduate students) for IOACDS total scores and Inspiration/Modeling and Support/Guidance subscale scores, one-way Analysis of Variance tests (ANOVA) was used. The section describing the people identified as influential in the participants' career choices was content analyzed. In order to describe the degree of influence those people had, frequency counts and percentages were calculated. In order to test the psychometric properties of the adapted version of the IOACDS, the Principle Components method of Factor Analysis with Varimax rotation was used.

CHAPTER THREE

Results

The purpose of the present study was to examine the source, nature, and degree of influence that role models/mentors have had on female graduate students' choice of science as a career. Also explored was the question of whether the influence of role models/mentors differed between male and female science graduate students in general and within the biological and physical sciences. A related purpose of this study was to test the validity and reliability of the adapted version of the Influence of Others on Academic and Career Decisions Scale (Nauta & Kokaly, 2001) on a graduate student population.

Professional Data

Approximately 832 surveys were distributed to graduate students enrolled in 21 programs in the computer science, mathematics/statistics, biological sciences (biology, biochemistry, microbiology, physiology, and anatomy), physical sciences (physics, chemistry, oceanography, and earth sciences), and engineering (industrial, chemical, civil, electrical, internetworking, petroleum, biomedical, biological, food science, and engineering math) departments of Dalhousie University. Of the 832 surveys distributed, via direct contact at seminars or mailboxes, 371 (44.6%) were returned. This return rate is only an estimate because, given the method of distribution and the fact that the respondents were anonymous, it is possible, although unlikely, that participants may have completed the survey more than once. Of the 371 surveys returned, 24 were discarded due to incompleteness (i.e., not all three parts of the survey were completed) leaving a final sample of 347 surveys for data analysis.

Table 2 displays the characteristics of the 371 participants in this study. Graduate student enrollment by department was 139 (37.5%) for engineering, 87 (23.5%) for biological sciences, 69 (18.6%) for computer science, 60 (16.2%) for physical sciences, and 16 (4.3%) for mathematics/statistics. The 21 programs in the engineering, computer science, mathematics/statistics, biological and physical sciences were later grouped into three main categories in order to ensure large enough sample sizes. The three new program categories, or areas of study, are the following: engineering, biological sciences, and physical sciences (which now also included computer science and mathematics/statistics). The break down of participants in these three categories are: 139 or 37.5% (98 or 70.5% male; 41 or 29.5% female) in engineering, 145 or 39.1% (93 or 64.2% male; 52 or 35.8% female) in the physical sciences, and 87 or 23.5% (39 or 44.8% male; 48 or 55.2% female) in the biological sciences. These categories were created following Statistics Canada's categorization of major fields of study (2001 Census of Population Products and Services).

Although the majority of the students had received their undergraduate degrees from Canadian universities (206 students or 56.7%), a large number of students had completed their undergraduate studies in foreign universities, especially China. A total of 77 or 21.2% students received their undergraduate degree from a Chinese university. This is not surprising, given the fact that only half the students were born in Canada (181 or 49.7%) and spoke English as their first language (189 or 51.9%). A large number of students were born in China (81 or 22.3%) and indicated Chinese as their first language (83 or 22.8%). Modal characteristics indicate that the typical respondent was between the ages of 21 and 30, was enrolled in a Masters program (231 or 62.3%), and had

Table 2

Characteristics of Graduate Science Students in Study

Characteristics	*N*	%
Age		
21-25	143	38.6
26-30	147	39.7
31-35	54	14.6
36-40	18	4.9
41 or more	8	2.2
Level of Study		
Masters	247	66.6
PhD	124	33.4
Area of Study		
Biological sciences	87	23.5
Male	39	44.8
Female	48	55.2
Physical sciences	145	39.1
Male	93	64.2
Female	52	35.8
Engineering	139	37.5
Male	98	70.5
Female	41	29.5
Country of Undergraduate Studies		
Canada	206	56.7
China	77	21.2
Other Non-Canadian	80	22.0
Country of Birth		
Canada	181	49.7
China	81	22.3
Other Non-Canadian	102	28.0
First Language		
English	189	51.9
Chinese	83	22.8
Other	92	25.3
Decided on Career		
Yes	224	60.5
No	146	39.5
Area of Chosen Career		
Academia	56	25.5
Industry	142	64.5
Further Studies	22	10.0

Note. Total N varies slightly per category as not all participants completed questions in each category.

decided on their choice of career (224 or 60.5%). Of those who had decided on their career, 56 (25.5%) indicated that they would like to work in academia (teaching and conducting research), 142 (64.5%) indicated that they would like to work in industry, and 22 (10%) indicated that they would like to pursue further studies in another field (e.g., education or health professions).

Analysis of Research Questions

Three research questions addressed in this study are:

Research Question 1: What are the psychometric properties of the adapted version of the IOACDS with this sample of graduate science students?

The psychometric properties of the adapted version of the IOACDS were assessed using a principal components factor analysis with a varimax rotation. The decision to conduct a factor analysis was based on the number of returns. The rule of thumb is to have at least 10 respondents per item in a questionnaire (Nunnally, 1978; MacCleave, 2001). With 347 useable returns, the minimum number of respondents required for a factor analysis was far exceeded. First, a principal components method of factor analysis was performed to extract initial component factors. Decisions concerning the number of factors to extract for further rotation were based on an examination of the eigenvalues and scree plot of the factor extraction data. Only three factors of the unrotated solution had eigenvalues above 1. An eigenvalue of 1.0 or greater indicates that the factor possesses at least as much total variance as contained in a single item (Huck, 2000). The eigenvalues for the first three factors extracted by this procedure were 5.52, 2.31, and

1.03. Examination of the scree plot indicated a distinct separation of the first three factors and a gradual leveling off after the third factor.

The next step in the factor analysis was to perform a varimax rotation in order to arrive at a final factor solution. Rotation provided a basis for finding more interpretable factors while keeping the number of factors fixed. Varimax rotation was performed to maximize the number of high loadings on each factor and minimize loading ambiguity. A two factor solution appeared to provide the most interpretable configuration of variable clusters as the third factor had a number of ambiguous loadings. Factor I, renamed the "Mentor" factor, accounted for 28.6% of the variance among the items after rotation. Factor II, renamed the "Role Model" factor, accounted for 23.6% of the variance among the items after rotation. Table 3 displays the eigenvalues, proportion of total variance, and cumulative proportion of variance accounted for by the individual factors in the rotated factor solution. These variances are similar to the ones found in the original IOACDS where Factor 1, originally the Support/Guidance factor, accounted for 37% of the variance after rotation and Factor II, the Inspiration/Modeling factor, accounted for 20% of the variance after rotation.

Inclusion of items on a factor was based on the criteria that only variables with factor loadings of .40 or greater could be included in the factor (Huck, 2000) and that if items had similar loadings on the two factors, they had to be eliminated. Of the fifteen variables included in the two-factor rotation, a total of 13 met the criteria for inclusion in a factor. Two of the fifteen items of the IOACDS-adapted version ("There was no one who showed me how to get to where I am going with my education/career." and "I had a

Table 3

Eigenvalues, Proportion of Total Variance, and Cumulative Proportion of Total Variance of Rotated Factor Solution

Factor	*Eigenvalue*	*Proportion of Total Variance*	*Cumulative Proportion of Total Variance*
1	4.29	28%	28%
2	3.54	23.6%	51.6%

mentor in my academic/career field.") were discarded because they did not load highly on either factor. Interestingly, these two items had the lowest eigenvalues in the original IOACDS, which could explain why they loaded so ambiguously in the factor analysis of the IOACDS adapted version. Consequently, thirteen items were retained for final analysis (seven items for Factor 1 and six items for Factor 2). Table 4 lists the items of the two factors with their loadings and eigenvalues. As indicated in Table 4 both factors have items with high to moderately high loadings and both have enough items to form two distinct, meaningful clusters. The results of the factor analysis on the IOACDS adapted version corroborate Nauta's finding that role models and mentors are two distinct entities that influence students in distinctly different ways.

Factor scores, rather than total or subscale scores, were used on subsequent analyses of the IOACDS adapted version. Factor scores were generated for the two rotated factors. According to MacCleave-Frazier (1985), "factor scores expressed as standardized scores or Z scores indicate a subject's position in a given distribution". (p.90). This decision was made because it was determined that weighted item scores, of which the factor scores were comprised, provided a more accurate reflection of the actual value each item had in contributing to the overall score on a factor than simple item scores. In other words, factor scores more accurately capture the variation in the data set.

Table 4

Two Factors of IOACDS (adapted version) with Items and Factor Loadings

Number	*Item*	*Loading*
	Factor 1: Mentor	
1.	There was someone I could count on to be there if I needed support when I made academic/career choices.	.766
3.	There was someone who supported me in the academic/career choices I made.	.795
8.	There was no one who supported me when I made academic/career decisions.	.653
11.	There was someone who helped me consider my academic/career options.	.678
13.	There was someone who helped me weigh the pros ands cons of academic/ career choices I made.	.665
14.	There was someone who stood by me when I made important academic/career decisions.	.769
15.	There was someone who told me or showed me general strategies for a successful life.	.670
	Factor 2: Role Model	
4.	There was no one I was trying to be like in my academic/career pursuits.	.726
6.	There was someone I was trying to be like in my academic/career pursuits.	.788
7.	In the academic/career path I am pursuing, there was someone I admire.	.709
9.	I knew of someone who had a career I wanted to pursue.	.686
10.	In the academic/career path I am pursuing, there was no one who inspired me.	.615
12.	There was no one particularly inspirational to me in the academic/career path I am pursuing.	.658

Research Question 2a: Are there differences in factor scores on the IOACDS (adapted version) between male and female science graduate students?

A one way analysis of variance test (ANOVA) was used to compare factor scores on the IOACDS (adapted version) by gender. A summary of the ANOVA analysis is presented in Table 5. Significant gender differences were found on scores for Factor 2, the Role Model factor, with more males than females identifying role models as having influenced their academic/career decisions. No significant gender differences were found on scores for Factor 1, the Mentor factor. Although not significant, females had higher mean scores on the Mentor factor, indicating a tendency in this direction.

Research Question 2b: Are there differences in factor scores on the IOACDS (adapted version) between graduate students in different areas of study (i.e., biological science, physical science, and engineering)?

A one way analysis of variance test was also used to compare factor scores on the IOACDS (adapted version) by area of study. Least Squares Means procedure was used as the follow-up Post-Hoc test to indicate which groups had significant mean differences. A summary of the ANOVA analysis is presented in Table 6. Significant area of study differences were found on scores for Factor 1, the Mentor factor, with more engineering and biological science students than physical science students identifying mentors as having influenced their academic/career decisions. No significant area of study differences were found on scores for Factor 2, the Role Model factor. No significant Gender x Area of Study interactions were found for either factor.

Table 5

ANOVA Comparing Factor Scores on the IOACDS (adapted version) by Gender

Gender	*N*	*M*	*SD*	*df*	*F*	*p*
			Factor 1: Mentor			
Male	224	16.930	4.589	1	2.18	.1403
Female	135	17.806	4.410	1	2.18	.1403
			Factor 2: Role Model			
Male	218	13.087	3.092	1	9.11	.0027**
Female	134	12.097	3.083	1	9.11	.0027**

Note.**p<.01; N varies because incomplete surveys had to be discarded.

Table 6

ANOVA Comparing Factor Scores on the IOACDS (adapted version)

by Area of Study

Area of Study	*N*	*M*	*SD*	*df*	*F*	*p*
			Factor 1: Mentor			
Engineering	134	17.752	4.464	2	4.03	.0187*
Physical	140	16.376	4.637	2	4.03	.0187*
Biological	85	17.938	4.292	2	4.03	.0187*
			Factor 2: Role Model			
Engineering	133	12.910	3.214	2	0.67	0.5127
Physical	137	12.459	3.176	2	0.67	0.5127
Biological	82	12.806	2.875	2	0.67	0.5127

Note.*$p<.05$; N .varies because incomplete surveys had to be discarded

Research Question 3a: Are there differences in the types of role models and mentors identified as having been the most influential in career decisions between male and female science graduate students?

A one way analysis of variance tests (ANOVA) was used to compare the types of role models and mentors identified by gender. A summary of this ANOVA analysis is presented in Table 7. Significant gender differences were found for the types of role models identified. More females than males identified female academic advisors as influential for their career decisions.

Significant gender differences were also found for the types of mentors identified. More females than males identified female "others" (i.e., coaches and chaplains) as influential for their career decisions.

Research Question 3b: Are there differences in the types of role models and mentors identified as having been the most influential in career decisions between graduate students in different areas of study (i.e., biological science, physical science, and engineering)?

A one way analysis of variance test was also used to compare the types of role models and mentors identified by area of study. Least Squares Means procedure was used as the follow-up Post-Hoc test to indicate which groups had significant mean differences. A summary of this ANOVA analysis is presented in Table 8. Significant area of study differences were found for the types of role models identified. More engineering than physical science students identified female peer role models as having

Table 7

ANOVA Comparing Types of Role Models and Mentors Identified by Gender

Gender	*N*	*M*	*SD*	*df*	*F*	*p*
			Role Model (female academic advisor)			
Male	159	3.283	0.969	1	6.54	.0111*
Female	88	3.614	0.863	1	6.54	.0111*
			Mentor (female "other")			
Male	28	2.929	0.900	1	5.70	.0237*
Female	7	3.714	0.951	1	5.70	.0237*

Note. $*p<.05$.

Table 8

ANOVA Comparing Types of Role Models and Mentors Identified

by Area of Study

Area of Study	*N*	*M*	*SD*	*df*	*F*	*p*
			Role Model (female peer)			
Engineering	4	4.750	0.500	2	12.30	.0195*
Physical	4	3.750	0.500	2	12.30	.0195*
Biological	1	5.00	0.000	2		

Note.*$p<.05$.

influenced their career decisions. It should be noted, however, that the number of students who indicated female peer role models was relatively small, so that caution should be taken in interpreting these results. When comparing mentors by area of study, however, no significant differences were found. No significant Gender x Area of Study interactions were found for either types of role models or mentors.

Analysis of Emergent Research Questions

Further examination of the characteristics of the participants involved in study led to the formulation of two additional research questions. These will be called "Emergent Research Questions" as they emerged out of, but are only partially answered by, the present data. Since graduate students who had completed their undergraduate studies in China represented a sizeable and distinct cluster, the decision was made to examine how their scores differed from graduate students who had completed their undergraduate studies in Canadian or other non-Canadian countries. Graduate students who had completed their undergraduate studies in other non-Canadian countries did not have sizeable enough numbers to warrant forming separate non-Canadian country categories.

Emergent Research Question 1: Are there differences in factor scores on the IOACDS (adapted version) between students who had completed their undergraduate studies in different countries (i.e., Canada, China, other non-Canadian universities)?

A one way analysis of variance tests (ANOVA) was used to compare factor scores on the IOACDS (adapted version) by undergraduate country. Least Squares Means procedure was used as the follow-up Post-Hoc test to indicate which groups had significant mean differences. A summary of the ANOVA analysis is presented in Table 9.

Significant undergraduate country differences were found on factor scores for Factor 1, Mentor factor, with more Canadian undergraduates than Chinese or other non-

Canadian undergraduates identifying mentors as having influenced their career decisions.

Significant undergraduate country differences were found on factor scores for Factor 2, the Role Model factor, with more Chinese undergraduates than Canadian or other non-Canadian undergraduates identifying role models as having influenced their career decisions.

Emergent Research Question 2: Are there differences in the types of role models and mentors identified as having been the most influential in career decisions between students who had completed their undergraduate studies in different countries (i.e., Canada, China, other non-Canadian universities)?

A one way analysis of variance tests (ANOVA) was used to compare the types of role models and mentors identified by undergraduate country. Least Squares Means procedure was used as the follow-up Post-Hoc test to indicate which groups had significant mean differences. A summary of this ANOVA analysis is presented in Table 10.

Significant undergraduate country differences were found for the types of role models identified. More Canadian undergraduates than Chinese undergraduates

Table 9

ANOVA Comparing Factor Scores on the IOACDS (adapted version)

by Undergraduate Country

Undergraduate Country	*N*	*M*	*SD*	*df*	*F*	*p*
			Factor 1: Mentor			
Canada	200	18.515	4.072	2	19.45	.0001**
China	76	15.185	4.466	2	19.45	.0001**
Other Foreign	76	16.235	4.734	2	19.45	.0001**
			Factor 2: Role Model			
Canada	196	12.383	3.143	2	4.52	.0116*
China	75	13.621	2.693	2	4.52	.0116*
Other Foreign	74	12.518	3.270	2	4.52	.0116*

Note.**p<.01.

Table 10

ANOVA Comparing Types of Role Models and Mentors Identified by Undergraduate Country

Undergraduate Country	*N*	*M*	*SD*	*df*	*F*	*p*
			Role Model			
			Female Academic Advisor			
Canada	128	3.523	0.913	2	3.12	0.0461*
China	63	3.175	0.993	2	3.12	0.0461*
Other Foreign	50	3.320	0.913	2	3.12	0.0461*
			Male Undergraduate Professor			
Canada	189	4.074	0.872	2	15.80	0.0001**
China	70	3.400	0.954	2	15.80	0.0001**
Other Foreign	68	3.691	0.902	2	15.80	0.0001**
			Female Undergraduate Professor			
Canada	156	3.577	0.944	2	4.81	0.0088**
China	62	3.145	0.973	2	4.81	0.0088**
Other Foreign	53	3.321	1.034	2	4.81	0.0088**
			Male Graduate Professor			
Canada	188	4.085	0.829	2	4.86	0.0083**
China	68	3.691	0.981	2	4.86	0.0083**
Other Foreign	69	3.913	1.025	2	4.86	0.0083**
			Mentor			
			Male Undergraduate Professor			
Canada	173	3.977	0.908	2	9.29	0.0001**
China	68	3.456	0.836	2	9.29	0.0001**
Other Foreign	62	3.613	1.014	2	9.29	0.0001**
			Male Graduate Professor			
Canada	171	3.930	0.878	2	4.10	0.0176*
China	64	3.545	0.925	2	4.10	0.0176*
Other Foreign	63	3.778	1.023	2	4.10	0.0176*

Note. $^{*}p<.05$. $^{**}p<.01$.

identified female academic advisors, male undergraduate professors, female undergraduate professors, and male graduate professors as having influenced their career decisions.

Significant undergraduate country differences were found for the types of mentors identified. More Canadian undergraduates then Chinese undergraduates identified male undergraduate professors and male graduate professors as having influenced their career decisions.

CHAPTER FOUR

Summary and Discussion

The purpose of the present study was to examine the source, nature, and degree of influence that role models/mentors have had on female graduate students' choice of science as a career. Also explored was the question of whether the influence of role models/mentors differed between male and female science graduate students in general and within the biological and physical sciences. A related purpose of this study was to test the validity and reliability of the adapted version of the Influence of Others on Academic and Career Decisions Scale (Nauta & Kokaly, 2001) on a graduate student population.

The participants for this study were male and female graduate students pursuing Masters or Doctoral degrees in 21 programs in the areas of engineering, physical science and biological science. The participants were graduate students in the science programs of Dalhousie University in Halifax, Nova Scotia. Dalhousie was selected in particular because it has the greatest number and largest variety of graduate programs in the region.

Once ethical approval was granted, the researcher conducted a pre-test of the survey on a sample of 17 graduate education students enrolled in a Research Literacy course (GEDU 6170) at Mount Saint Vincent University. The purpose of the pre-test was to establish the content validity of the questions in the survey and to determine the average amount of time it took to complete the survey. The final version of the survey was sent to the Dean of Sciences at Dalhousie University for third party approval. Once third party approval was granted, the researcher contacted the department heads, coordinators, and professors of the 21 science departments selected for the study. In the span of approximately one month (March 25 - April 18, 2003), the researcher distributed the surveys to the graduate students of the various departments either by attending seminars or by mailbox distribution.

Approximately 832 surveys were distributed to graduate students enrolled in 21 programs in the computer science, mathematics/statistics, biological sciences (biology, biochemistry, microbiology, physiology, and anatomy), physical sciences (physics, chemistry, oceanography, and earth sciences), and engineering (industrial, chemical, civil, electrical, internetworking, petroleum, biomedical, biological, food science, and engineering math) departments of Dalhousie University. Of the 832 surveys distributed, via direct contact at seminars or mailboxes, 371 (44.6%) were returned. This return rate is only an estimate because, given the method of distribution and the fact that the respondents were anonymous, it is possible, although unlikely, that participants may have completed the survey more than once. Of the 371 surveys returned, 24 were discarded due to incompleteness leaving a final sample of 347 surveys for data analysis.

Graduate student enrollment by department was 37.5% for engineering, 23.5% for biological sciences, 18.6% for computer science, 16.2% for physical sciences, and 4.3% for mathematics/statistics. The 21 programs in the engineering, computer science, mathematics/statistics, biological and physical sciences were later grouped into three main categories in order to ensure large enough sample sizes. The three new program categories, or areas of study, are the following: engineering, biological sciences, and physical sciences (which now also included computer science and mathematics/statistics). The break down of participants in these three categories are:

37.5% (70.5% male; 29.5% female) in engineering, 39.1% (64.2% male; 35.8% female) in the physical sciences, and 23.5% (44.8% male; 55.2% female) in the biological sciences.

Although the majority of the students had received their undergraduate degrees from Canadian universities (56.7%), a large number of students had completed their undergraduate studies in foreign universities, especially China. A total of 21.2% students received their undergraduate degree from a Chinese university. This finding is not surprising, given the fact that only half the students were born in Canada (49.7%) and spoke English as their first language (51.9%). A large number of students were born in China (22.3%) and indicated Chinese as their first language (22.8%). Modal characteristics indicate that the typical respondent was between the ages of 21 and 30, was enrolled in a Masters program (62.3%), and had decided on their choice of career (60.5%). Of those who had decided on their career, (25.5%) indicated that they would like to work in academia (teaching and conducting research), (64.5%) indicated that they would like to work in industry, and (10%) indicated that they would like to pursue further studies in another field (e.g., education or health professions).

The results of the three research questions developed to guide this study, as well as the two emergent questions that arose from the study, are summarized and discussed as follows:

Research Question 1: What are the psychometric properties of the adapted version of the IOACDS with this sample of graduate science students?

The results of the factor analysis on the IOACDS adapted version corroborate Nauta's finding that role models and mentors are two distinct entities that influence students in distinctly different ways.

The two-factor solution that emerged from the principal-component factor analysis of the adapted version of the IOACDS was similar to Nauta et al's factor analysis of the original IOACDS. The "Mentor" factor paralleled Nauta et al's "Support/Guidance" factor while the "Role Model" factor corresponded to Nauta et al's Inspiration/Modeling" factor. This factor solution was a notable outcome of this study.

Although Nauta et al reported this two-factor solution, the salience of this factor pattern was largely ignored. The terms "role modeling" and "mentoring" were often used interchangeably in previous research whereas the factor solution of both Nauta et al and the current study indicate that graduate students responded to the role modeling and mentoring items as distinct entities. This factor solution also lends support and focused attention to the "learning/modeling" and "verbal persuasion/support from others" self-efficacy factors outlined in Bandura's Social Learning Theory in that they closely parallel the "role model" and "mentor" factors in this study.

Consideration of these distinctions have implications for educational practices and the conduct of further research in this area. The "role model" and "mentor" factors, unlike other factors (such as social influences outside of the university setting), are more within the control of universities and program areas. Potentially, interventions could be developed to enhance role model and mentor influences within the university setting.

Research Question 2a: Are there differences in factor scores on the IOACDS (adapted version) between male and female science graduate students?

Significant gender differences were found on scores for Factor 2, the Role Model factor, with more males than females identifying role models as having influenced their academic/career decisions. No significant gender differences were found on scores for Factor 1, the Mentor factor. Although not significant, females had higher mean scores on the Mentor factor, indicating a tendency in this direction.

One obvious explanation for males being more influenced by role models than females is that there are more male role models in these programs and therefore they would naturally weald more of an influence. Alternatively, perhaps it is not so much the quantity but the qualities of role models that somehow influence males more than females. Perhaps it is sufficient for males to observe and emulate someone they admire, whereas females may require the more "hands-on", personal approach of mentors.

Although literature supports the importance of female role models (Almquist & Angrist, 1971; Ehrhart & Sandler, 1987; Nauta et al, 1998), the tendency in this study of more females than males being influenced by mentors is promising. While the reason for this tendency is unclear (i.e., Are females selecting mentors in order to compensate for the lack of female role models or are they selecting mentors because of the more "female friendly" qualities mentors may possess?), the implications for university practice are very clear. More attention could be focused on encouraging and developing mentorship qualities in professionals within the university setting.

Research Question 2b: Are there differences in factor scores on the IOACDS (adapted version) between graduate students in different areas of study (i.e., biological science, physical science, and engineering)?

Significant area of study differences were found on scores for Factor 1, the Mentor factor, with more engineering and biological science students than physical science students identifying mentors as having influenced their academic/career decisions. No significant area of study differences were found on scores for Factor 2, the Role Model factor. No significant Gender x Area of Study interactions were found for either factor.

With regards to program area differences, it is possible that engineering and biological science programs may be putting a greater emphasis on mentoring their students than physical science programs. Further study of mentoring within the particular programs would be necessary in order to gain a better understanding of this difference. However, no matter what the area of study, instructional practices and class size indirectly influence the quality of mentorship available to the students. Regarding instructional practices, having tutorials and group work in addition to lectures would naturally provide more opportunities for mentoring by professors, teaching assistants, and peers. As for class size, a smaller student-instructor ratio, such as found in laboratory settings, would also provide more mentoring opportunities.

Research Question 3a: Are there differences in the types of role models and mentors identified as having been the most influential in career decisions between male and female science graduate students?

Significant gender differences were found for the types of role models identified. More females than males identified female academic advisors as influential for their career decisions. Significant gender differences were also found for the types of mentors identified. More females than males identified female "others" (i.e., coaches and chaplains) as influential for their career decisions.

The identification of females with female academic advisors is not surprising considering the literature on role model influence (i.e., that one is more likely to identify with a role model who is of the same gender as oneself). Further research pertaining to this finding could be the specific study of academic advisors in the university setting. Do they have particular characteristics that make them more accessible to or more influential with female university students than with males (i.e., gender, age, communication style, more collaborative than directive problem solving style)?

One explanation for the finding that more females than males identified the influence of female "others" could be that female students may not have found enough role models or mentors in the university setting and therefore felt the need to seek advice from people outside of the university setting. A further study could also examine whether female students in general are more likely to seek advice from others than are male students. For example, the literature (i.e., Perrone et al, 2002; Ulku-Steiner et al, 2000; Reskin, 1979) shows that females tend to gravitate towards more collaborative than competitive problem solving and appear to problem solve best when they can "talk things out".

Research Question 3b: Are there differences in the types of role models and mentors identified as having been the most influential in career decisions between graduate students in different areas of study (i.e., biological science, physical science, and engineering)?

Significant area of study differences were found for the types of role models identified. More engineering than physical science students identified female peer role models as having influenced their career decisions. When comparing mentors by area of study, however, no significant differences were found. No significant Gender x Area of Study interactions were found for either types of role models or mentors.

One explanation for the greater identification with female peer role models by engineering than by physical science students could be that because of the lack of female role models within the university setting, students tended to seek advice from their female peers. These peers perhaps displayed more collaborative problem solving styles than their more competitive male counterparts. It might be interesting to examine the extent to which programs incorporate collaborative problem-solving with their instructional practices. For example, are study groups and other forms of group work encouraged? If so, males as well as females could be socialized into a more collaborative approach.

Emergent Question 1: Are there differences in factor scores on the IOACDS (adapted version) between students who had completed their undergraduate studies in different countries (i.e., Canada, China, other non-Canadian universities)?

Significant undergraduate country differences were found on factor scores for Factor 1, Mentor factor, with more Canadian undergraduates than Chinese or other non-Canadian undergraduates identifying mentors as having influenced their career decisions. Significant undergraduate country differences were found on factor scores for Factor 2, the Role Model factor, with more Chinese undergraduates than Canadian or other non-Canadian undergraduates identifying role models as having influenced their career decisions.

This finding raises the following questions: Is mentoring predominantly a Western or North American concept? Is role model influence more salient in Chinese culture? Perhaps it is not necessarily the salience but simply the number of role models/mentors available to undergraduate students in their respective cultures that is important. What is the gender composition in Chinese and other non-Canadian undergraduate programs? Are there more female science instructors in Chinese undergraduate science programs? Are science classes larger in China? If so, there would be less opportunity for one-on-one mentoring. Although some mentoring may be taking place in lab settings, might the lecturer be perceived as having relatively greater status and authority? These questions point to complex cultural influences that would require further examination.

Emergent Question 2: Are there differences in the types of role models and mentors identified as having been the most influential in career decisions between students who had completed their undergraduate studies in different countries (i.e., Canada, China, other non-Canadian universities)?

Significant undergraduate country differences were found for the types of role models identified. More Canadian undergraduates than Chinese undergraduates identified female academic advisors, male undergraduate professors, female undergraduate professors, and male graduate professors as having influenced their career decisions. Significant undergraduate country differences were found for the types of mentors identified. More Canadian undergraduates than Chinese undergraduates identified male undergraduate professors and male graduate professors as having influenced their career decisions.

On the surface, the results of Emergent Question 2 may seem contradictory to the results of Emergent Question 1. How can it be that when asked to indicate the type and degree of influence of role models versus mentors in the university setting on their career choices, graduate students from Canadian undergraduate institutions (who had identified mentors as having influenced their career choices more then role models in Emergent Question 1) now indicated specific role models as having influenced their career more than mentors? One possible reason for this is that when considered collectively, role model influences on career decisions of graduate students who attended Canadian undergraduate programs was not statistically significant. However, when specific types of role models were analyzed, statistically significant influences on career choices were revealed. Might this latter finding indicate that graduate students who attended Chinese undergraduate programs selected role models across all types instead of concentrating on a few? Conversely, graduate students who attended Canadian undergraduate programs may have selected certain role models exclusively to the point that these influences were statistically significant? Further research would be needed to examine these influences more fully.

Another interesting finding from Emergent Question 5 was that when types of mentors were shown to have a significant influence on graduate students' career choices, the gender of the mentor was not an issue. This finding may indicate that mentoring as a practice makes an important difference, regardless of the gender of the mentor. Consequently, when male professors mentor, they may help compensate for the lack of female role models or availability of female mentors.

Implications For Practice

The findings of this study provide many implications for practice. Although research to date indicated that researchers, and perhaps practitioners, had considered role models and mentors to be one and the same, this study has confirmed that their qualities and, as a result, their types of influence, are different and need to be examined further.

The finding that significantly more male undergraduate students were influenced by role models in their academic/career choices and that more females tended to be influenced by mentors raises many questions. Is the degree of influence based on the availability of role models/ mentors (i.e., there were more male role models, so males were more influenced by them) or the qualities that the role models/ mentors possess (i.e., perhaps the inspiration and modelling qualities of role models appeal more to males and the encouragement and support qualities of mentors appeal more to females)? If, in fact, the degree of influence is based on quality not quantity, then even if there are not enough female role models in the sciences, the qualities of a mentor, regardless of their gender, would be enough, and should be encouraged, until a more critical mass of female scientists is reached.

The idea that mentor and role model influences may be based on quality was supported by the qualitative study of Zeldin and Pajares (2000). The 15 STEM career women interviewed neither recalled nor required exclusively female role models. The researchers noted too:

> The influence had less to do with gender and more to do with the quality of the message women received about their capabilities. Men who demonstrated confidence in womens' abilities were perceived to be just as positive and self-efficacy enhancing as were influencial women. (p 240)

Not only is the quality of role model and mentor influences important but female students may benefit from a more "hands-on" encouraging, supportive person in making their academic and career decisions. According to the literature (Perrone et al, 2002; Ulku-Steiner et al, 2000; Reskin, 1979), females appear to benefit from a different type of learning environment (i.e., more collaborative, less competitive). Therefore, it warrants further research to examine how the university learning environment influences women's choice of, and persistence in, academic and career pursuits.

This line of inquiry may be fruitful because Gess-Newsome, Southerland, Johnston, and Woodbury (2003) found that the personal system of beliefs (about teaching/ learning and their subject areas) had the most powerful influence on instructional practice and change among college science instructors. Some general instructional practices that would increase the involvement of all students with the instructor and the material being taught would be to have small group and/or tutorials in addition to lectures, relating instructional materials to students' life experiences, and demonstrating the practical applications of theoretical constructs. Some general institutional practices that would make the learning environment more inclusive to all minorities, including women, would be to increase the sensitivity of faculty, administration, and "majority" students to the needs of "outsiders" and to decrease the overt and subtle discrimination of underrepresented groups (Betz, 1997; Williams & Emerson, 2002).

The finding that different types of mentors and role models exacted differing degrees of influence (especially the finding that some females cited female peers and female academic advisors as having influenced their career decision) underlines the importance of further examining not only the distinctive qualities of role models and mentors but the different types of each. With regards to implications for practice in the university setting, this would mean further examination and subsequent utilization of the different types of role models/mentors that may exist inside and outside of the university setting.

Lastly, the finding that students who had completed their undergraduate studies in different countries had indicated differing role model/mentor influences points to the importance of examining cultural differences in the hopes of learning and applying more positive practices. Among these positive practices may be curriculum adaptations that are better suited to female students and underrepresented ethnic or cultural groups (Muller, Stage, & Kinzie, 2001).

Limitations

Two main areas have been identified as possible limitations to this study: In general, the decision to use a quantitative, retrospective questionnaire for collecting the data. In particular, the types of questionnaires used (and the particular questions within them).

In general, some of the limitations to using a quantitative, retrospective questionnaire are the following: 1) Given the non-experimental nature of the study, only trends, not cause and effect relationships, could be discussed.; 2) Given the retrospective nature of the questionnaire (requesting that participants recall whether role models and/or mentors influenced their career choice) participants may have remembered the answers to the questions incorrectly, incompletely, or not at all; 3) Given the quantitative nature of the questionnaires, with most questions being specific and close ended, the opportunity to elaborate on answers or touch on influences not considered by the researcher was limited. Generalizability of the results of this study, as in all studies, was compromised for two reasons: Not everyone from the sample chose to participate in the study and those who did may have had particular characteristics that differed from those who did not. Science graduate students from only one university were selected. Therefore, generalizability of the results to other science graduate student populations would be limited.

In particular, the format of the questionnaires and the particular questions within them may have adversely affected the way in which participants interpreted and completed them. With regards to the IOACDS, several participants voluntarily criticised the repetitive nature of the questionnaire. For example, they pointed out that the sentence, "There is someone who helps me consider my academic and career options" varied only slightly in meaning to the sentence, "There is someone who stands by me when I make academic and career decisions." As well, the sentence, "There is no one who supports me in the academic and career choices I make." seemed unnecessary given that participants were also asked to rate the positive form of the sentence on a 5-point Likert scale with the number 1 indicating "strongly agree" and 5 indicating "strongly disagree".

Although the simplicity of the IOACDS may have limited its effectiveness, it was perhaps the complexity of the Career Choice Information questionnaire that may have negatively influenced its usefulness. Perhaps asking participants to select the type of role model/mentor separately from their degree of influence may have yielded clearer results.

An additional limitation to the study may have been the method of distribution of the questionnaire. Although great pains (filling mailboxes, attending seminars in different parts of the university campus) were taken to ensure that the survey was distributed to as many participants as possible, some did not receive it because they were not on campus to pick up the hard copy (some of the natural science students were away on field studies during the distribution period). The idea of using the internet as an alternative means of distribution was considered. However, the idea was dismissed when a means to ensuring confidentiality was not found.

Directions For Future Research

Several ideas for further research have come about as a direct and indirect result of this study.

Although the focus of this study was to examine the influence of role models and mentors on a particular sample of undergraduate students who chose science as a career, another population, as well as many other factors, would merit further examination.

With regards to factors influencing students' choice of science as a career, there are a myriad of factors other than role model/mentors that could have influenced their choice of career: academic ability, perceived ability, interest, socialization, societal pressures, financial pressures – to name a few. The interaction between current factors and factors that predate students' enrollment in university (e.g., academic ability before university, influence of parents and guidance counselors etc.) would be interesting to study as well.

Related to the influence of role models and mentors, it would be useful to further examine the various dimensions of the role model/mentor factor: the number of role models/mentors, at what point in their studies did the student and role model/mentor meet, the frequency with which they met, the qualities of an effective role model/mentor.

With regards to population, it would be interesting to examine other careers in which there are few women or, conversely, to examine careers in which there are few men. Although this study looked at those students who chose science as a career, it would be equally important to examine those students who completed their undergraduate degrees in science but chose not to pursue a career in it.

Given the finding of this study that students who had completed their undergraduate studies in Canadian, Chinese, and non-Canadian universities were influenced differently by role models and mentors, it would be useful to do a study on the cultural influences on career choice. An additional influence that might be examined in the choice of pursuing science at the graduate level is that of language. Are Chinese undergraduates more likely to select science when choosing to study in a foreign institution because language is perceived as a not as great a barrier in the sciences as it may be in the humanities?

Although this study looked at one aspect of the "pipeline" where females typically choose to pursue a career in science or not (i.e., the undergraduate years), it would also be important to conduct more extensive studies on women who are actually in STEM careers and the factors that influenced their choice of, and persistence in, their careers (the current literature is small and mainly based on case studies). To gain a completely different perspective, professors, academic advisors, or other professionals could be surveyed on their thoughts on what factors influence students' career choices.

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Appendix A: Information Letter

Influence of Others on Academic and Career Choices

I am a graduate student in the Masters of Arts in School Psychology program at Mount Saint Vincent University. As part of my thesis I am conducting a study on graduate science students' perceptions of how others may have influenced their academic and career choices. The findings of this study will increase our understanding of the influence of others on graduate student's academic and career choices and may aid universities in planning services that will help students choose and persist in science careers in the future.

The study involves completing a brief survey (it takes approximately 10 minutes to complete). Participation in this study is voluntary. You may skip any questions that you do not feel comfortable answering and you may discontinue participation at any time. In order to maintain confidentiality, I ask that you **do not put your name anywhere on this survey**. By completing and returning the survey, you have agreed to participate in the study.

If you have any questions or concerns regarding this study, please do not hesitate to contact me, Toni Fried, at (902) 425-2578 or my supervisor, Dr. Anne MacCleave, at (902) 457- 6182. This study has been reviewed and granted approval by the Mount Saint Vincent University Research Ethics Board. If you would like to speak to someone who is not directly involved in this study, please contact Dr. Stephen Perrott, Chair of Mount Saint Vincent University Research Ethics Board. at (902) 457-6337.

Thank you for your participation in this study.

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Appendix B: Survey

Section 1: Influence of Others on Academic and Career Decisions Scale - Adapted Version

On a 5-point continuum ranging from *strongly agree* (5) to *strongly disagree* (1), please indicate the extent to which you agree/disagree with each of the following statements.

5	4	3	2	1
strongly agree				*strongly disagree*

1.	There was someone I could count on to be there if I needed support when I made academic/career choices	5 4 3 2 1
2.	I had a mentor in my academic/career field.	5 4 3 2 1
3.	There was someone who supported me in the academic/career choices I made.	5 4 3 2 1
4.	There was no one I was trying to be like in my academic/career pursuits.	5 4 3 2 1
5.	There was no one who showed me how to get to where I am going with my education/career.	5 4 3 2 1
6.	There was someone I was trying to be like in my academic/career pursuits.	5 4 3 2 1
7.	In the academic/career path I am pursuing, there was someone I admired.	5 4 3 2 1
8.	There was no one who supported me when I made academic/career decisions.	5 4 3 2 1
9.	I knew of someone who had a career I wanted to pursue.	5 4 3 2 1
10.	In the academic/career path I am pursuing, there was no one who inspired me.	5 4 3 2 1
11.	There was someone who helped me consider my academic/career options.	5 4 3 2 1
12.	There was no one particularly inspirational to me in the academic/career path I am pursuing.	5 4 3 2 1
13.	There was someone who helped me weigh the pros and cons of the academic/ career choices I made.	5 4 3 2 1
14.	There was someone who stood by me when I made important academic/ career decisions.	5 4 3 2 1
15.	There was someone who told me or showed me general strategies for a successful life.	5 4 3 2 1

Section 2: Background Information

1) What is your gender? For office use only

☐ Male ☐ Female ___

2) What is your age?

☐ 20 or less ☐ 21-25 ☐ 26-30 ☐ 31-35 ☐ 36-40 ☐ 41 or more ___

3) What is your current level and year of study?

☐ Masters 1 2 3 4 5 6 ☐ PhD 1 2 3 4 5 6 ___ ___

4) What is the name of your degree program?

____ ___ ___

5) Name the institution where you completed your undergraduate degree.

____ ___ ___

6) What is your country of birth?

____ ___ ___

7) What is your first language?

____ ___ ___

Section 3: Career Choice Information

1) Have you decided on your choice of career?

☐ Yes ☐ No ___

If yes,

2) What is your chosen career?

____ ___ ___

Section 3: Career Choice Information continued

***A role model** is a person you know personally, or know of, who has influenced your career decisions by being admirable in one or more ways.* Within the university setting, to what extent have any of the following been a role model for you and your career, either in an encouraging or discouraging manner? Please circle the number that reflects your answer for each one selected. Select as many as apply.

5	4	3	2	1
encouraged me greatly	*encouraged me*	*did not encourage or discourage me*	*discouraged me*	*discouraged me greatly*

Male Academic Advisor	5	4	3	2	1
Female Academic Advisor	5	4	3	2	1
Male Undergraduate Professor	5	4	3	2	1
Female Undergraduate Professor	5	4	3	2	1
Male Graduate Professor	5	4	3	2	1
Female Graduate Professor	5	4	3	2	1
Male Other (Please indicate__________________)	5	4	3	2	1
Female Other (Please indicate__________________)	5	4	3	2	1

***A mentor** is a person who has influenced your career decisions by actively giving advice, encouraging (or discouraging), supporting, providing information, or helping you make decisions.* Within the university setting, to what extent have any of the following been a mentor for you and your career, either in an encouraging or discouraging manner? Please circle the number that reflects your answer for each one selected. Select as many as apply.

5	4	3	2	1
encouraged me greatly	*encouraged me*	*did not encourage or discourage me*	*discouraged me*	*discouraged me greatly*

Male Academic Advisor	5	4	3	2	1
Female Academic Advisor	5	4	3	2	1
Male Undergraduate Professor	5	4	3	2	1
Female Undergraduate Professor	5	4	3	2	1
Male Graduate Professor	5	4	3	2	1
Female Graduate Professor	5	4	3	2	1
Male Other (Please indicate__________________)	5	4	3	2	1
Female Other (Please indicate__________________)	5	4	3	2	1