Relationships between STEM self-efficacy, same-sex role models and academic behaviour

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Abstract

Although women make up approximately half of undergraduate enrollments in postsecondary educational institutions, women continue to be significantly underrepresented in many areas of science, technology, engineering and mathematics (STEM). In this study, survey responses from 249 undergraduate students enrolled in at least one STEM course were analyzed to further investigate possible relationships among sex, academic course choices, same-sex role models and STEM self-efficacy. Results show that female students were less likely than male students to declare a STEM major. Among female students there was a correlation between the number of same-sex instructors and being a STEM major as well as the number of STEM courses taken, and further investigation revealed that self-efficacy was a significant predictor of female undergraduate's major. Implications, future directions and study limitations are discussed.

Keywords: STEM; Self-efficacy; Sex; Gender; Role Models

This is dedicated to Iva,

missing you every day.

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Table of Contents

List of Tables

Chapter 1.

Introduction

1.1. Women and Education

Historically, men and women's education have followed quite different paths. Early philosophers, such as Aristotle, long ago cemented the assumption that women's biology made them more emotional, despondent and psychologically inferior to men, which he surmised made women best suited to rule domestic matters within the home (Mayhew, 2010). This sexist thinking meant women were not encouraged, or permitted in many cases, to pursue educational opportunities in the same way as men (Schiebinger, 1987). Such assumptions about the specific nature of women have persisted across centuries. Although universities in Western society have formally existed since as early as the 11th century (Università di Bologna, 2016), simply gaining admission to university remained a struggle for women, and it was not until 1875 that the first Canadian woman earned a university degree from Mount Allison University in New Brunswick (Guppy, Balson, & Vellutini, 1987).

Even as formal barriers to women's higher education were lifted throughout the late 19th and early 20th centuries, women's post-secondary participation rates lagged behind men's. In 1950 women made up nearly 22% of post-secondary undergraduate enrollments (Wisenthal, 1999), yet twenty years later women comprised merely just a third of college and university enrollments (Royal Commission on the Status of Women in Canada, 1970). Simply opening the doors to post-secondary education has not been enough to foster equal participation. To address women's disadvantage and underrepresentation within educational and vocational areas, the Royal Commission on the Status of Women in Canada (1970) made a number of recommendations aimed at reducing or removing systemic and institutional barriers to women's education and career participation. While not all of the recommendations outlined in this report were ultimately implemented, many recommendations were, and since then women have made significant gains in access to and representation in post-secondary education. In fact, the overall sex gap in Canadian post-secondary school attendance has reversed; women now represent just over half of the total post-secondary enrollment (Statistics Canada, 2016), with the percentage of female students as high as 75% in areas of Education and Health and 67% in Social and Behavioural Sciences, Performing Arts and Communications (Canadian Association of University Teachers [CAUT] Almanac, 2015).

1.1.1. Underrepresentation in STEM

With such large gains made by Canadian women in accessing post-secondary education, it is perhaps somewhat surprising that female undergraduates are still drastically underrepresented relative to their male counterparts in particular areas of science, technology, engineering, and math (STEM), such as computing and engineering (Department of Finance Canada, 2014; Statistics Canada, 2013). Nationally in 2015, female undergraduate students made up only 26% of enrollment in Mathematics and Computing Science faculties, and as few as 20% of enrollments in Engineering-related faculties (Statistics Canada, 2016). Specifically at Simon Fraser University (SFU), female undergraduates are at least as equally represented as their male peers in Faculty of Science departments such as biomedical physiology and kinesiology, and molecular biology and biochemistry. Yet they are significantly underrepresented in other Faculty of Science departments as well as within the Faculty of Applied Science. In particular, at SFU female undergraduate majors and minors account for only 15% of physics degrees, 17% and 19% of computing science and engineering degrees, respectively, and only 10% of mechatronics engineering degrees (Simon Fraser University, 2016)[1].

Women's participation in STEM throughout their educational and vocational careers is often described as a leaky pipeline. There is a noticeable decline in the number of girls and young women studying STEM at each stage of STEM education,

[1] Data from 2015/2016 academic year.

from high school to undergraduate studies, which continues into graduate studies and onto an academic career. The attrition from undergraduate to graduate studies is not as noticeable at SFU, although women are overall still underrepresented in a number of graduate STEM programs. Female graduate students make up 17% of masters degrees and 34% of doctorate degrees in physics, 24% and 23% of masters and doctorate degrees in computing science, 30% and 22% of masters and doctorate degrees in engineering, and 20% and 26% of masters and doctorate degrees in mechatronics engineering (Simon Fraser University, 2016)[2]. Yet further along the academic career path there is a noticeable decline in women working in faculty[3] positions within STEM disciplines at SFU. Overall the percentage of female faculty is lowest in science (26%), and applied science (17%; Simon Fraser University, 2016[4]). And the numbers of female faculty are even lower in specific STEM departments such as physics (18%), computing science (16%), engineering (21%), and mechatronics engineering (12%; Simon Fraser University, 2016). Similar statistics are reported at academic institutions throughout Canada (CAUT Almanac, 2015).

Implications

Even though overall women now attend post-secondary in approximately equal numbers as men, women's continued underrepresentation in STEM specifically is concerning for a number of reasons. Women's relative absence during the early emergence of STEM fields such as science and math has had very real effects on the development of science and scientific methodology. Even though science is thought to be objective, neutral, and lacking in political agenda, the discipline itself was shaped and evolved during a time when women were mainly excluded from pursuing higher education or from openly contributing to science. In this context, it is likely not surprising that traits considered synonymous with science were also those traits commonly associated with men, such as intellect and reason (Watts, 2007). Such qualities are in

[2] Data from 2015/2016 academic year.

[3] Refers to teaching categories of Professor, Associate Professor, Assistant Professor, Instructor, and Lecturer

[4] Data from 2015/2016 academic year.

direct contrast with "unscientific" traits, like emotion and instinct, which were mainly attributed to women and femininity.

Increasing women's representation in STEM will mean these fields will better represent the actual population, and also has other possible benefits. Greater group diversity has been found to significantly increase the complexity in collective domain-specific knowledge during work on a group project (Curşeu & Pluut, 2013), while high domain knowledge, in turn, has been found to correlate with creativity for complex open-ended problem-solving tasks (Schoen, 2015). Decisions made by more diverse groups are perceived by others to have higher validity (Lopes, Vala, Oberlé, & Drozda-Senkowska, 2014). But it also makes sense that, as diversity increases, so does the possibility of negative effects, such as increased conflict. Indeed, greater diversity in perspectives has been linked to greater negative affect amongst individuals in groups tasked with generating ideas (Harvey, 2013). However recent evidence indicates that negative effects of group diversity can be mitigated by the culture in which a group operates. For example, Nishii (2013) found environments with greater gender diversity had lower conflicts when inclusivity (such as integration of differences or equitable employment practices) was perceived to be high.

Contributing factors to low female involvement in STEM

To actively increase women's STEM participation and enable them to contribute their perspectives, skills and experiences, researchers have struggled to first understand why certain fields attract fewer women in the first place. The reasons why fewer women pursue STEM fields are complicated and have not yet been fully explained, and many researchers tend to assume fundamental differences between male and female students on various traits acts as a deterrent for women. Among the more common explanations of the STEM sex difference is that many STEM fields require strong mathematical abilities and males are naturally better at math than females. In support of the theory that women by nature have less aptitude for math, researchers have found correlations between mathematical ability or spatial tasks with exposure to type and amount of sex hormones (Heil, Kavšek, Rolke, Beste, & Jansen, 2011; Vuoksimaa et al., 2010) as well as the different structures and activation of the brains of men and women (Hahn, Jansen, & Heil, 2010). Such biological explanations are attractive due to their simplicity and their appeal to common assumptions about sex differences that many people feel to be true. Biological explanations alone are simply not sufficient to explain the STEM sex gap when considering that sex differences identified for some cognitive tasks have diminished or reversed over time, or differences are not found to be universal across cultures and nations, or the gap can be altered by specific situational cues (Ceci, Ginther, Kahn, & Williams, 2014; Miller & Halpern, 2014).

In contrast to biological explanations, other researchers hypothesize that the STEM sex gap is due to female students simply being less interested in STEM and as a result, girls may be less inclined to pursue these fields in higher education or as a career. There may be some truth to this, but the picture is complex. Both boys and girls generally have relatively positive attitudes about science during the elementary school years. Yet there is a marked decrease in both groups in positive attitudes upon entering middle school. An examination of science attitudes in elementary and middle school children shows that there is a significant decrease in interest in science between the ages of 11 and 12, the transition point from elementary to middle school (Sorge, 2007). This decrease occurs for both boys and girls; there appears to be no statistically significant difference between boys and girls with regard to attitudes towards science in elementary and in middle school (Sorge, 2007). However as children get older, a marked difference emerges between boys and girls in interest in pursuing a STEM career. By the time students begin high school, 39.5% of boys report interest in pursuing a career in a STEM field compared to 15.7% of girls (Sadler, Sonnert, Hazari, & Tai, 2012). And by the end of high school this disparity increases, with the percentage of boys reporting an interest in a STEM career having increased slightly to 39.7%, but the percentage of girls having dropped to 12.7% (Sadler, Sonnert, Hazari, & Tai, 2012). It is interesting that even though girls and boys have similar attitudes toward science at the end of middle school, before entering high school, girls at this age are still less likely to report a desire for a STEM career.

These findings are important because they suggest that female students are losing interest in STEM careers at some point during middle and high school, a sensitive time for planning their future studies because many introductory post-secondary STEM courses require students to have completed higher level math and science prerequisites in high school. And there is indeed a strong correlation between the number of math and science courses taken in high school and entrance into STEM fields in post-secondary school (Wang, 2013). However, in spite of the fact that female high school students are less likely to report a desire to pursue a STEM career, they are still equally as likely as male students to complete higher-level math and science courses in high school (Tyson, Lee, Borman, & Hanson, 2007).

While some standardized tests indicate a male advantage in math (Organization for Economic Co-operation and Development [OECD], 2015), other studies show that female students perform as well as (Cotton, McIntyre, & Price, 2013; O'Grady & Houme, 2014), or better than (Voyer & Voyer, 2014), male students at math. Based on these conflicting findings one cannot assume that female students exhibit lower achievement in such classes that might prevent them from developing the essential foundational STEM skills, such as math, to better enable them to pursue a STEM degree or career.

It is clear something other than interest in, and aptitude for, STEM is influencing girls and young women to steer away from pursuing STEM to the same extent as boys and young men. One possible explanation is that girls and young women are not exposed to many female STEM role models, and as a result degrees and occupations in STEM do not occur to them as attainable or realistic choices.

1.2. Role Models

A role model is defined as someone who exemplifies success that one may achieve and who provides one with examples of the traits necessary to achieve such success (Lockwood, 2006). An important part of this definition is that role models exemplify what one *may* achieve, not necessarily what one thinks they *will* achieve. According to this definition, role models can introduce possibilities which individuals might not have otherwise considered, an important reason why having access to complex and varied role models is so important. It is vitally important that young girls and women have visible role models to become aware of the varied educational and career paths that are available to them and to realize their potentials.

The lack of female STEM role models for young girls and women perpetuates an ongoing cycle; few women in STEM means few STEM role models are available to girls, resulting in few girls entering STEM, and there being fewer role models, and so on. And this relative absence of women in certain areas impacts many areas of girls' educational and vocational development, where the lack of varied female models available to young girls and women has long been a focus of consideration. For example, a report submitted by the Royal Commission on the Status of Women (1970) criticized the depiction of women in some Canadian textbooks as one-dimensional and passive compared to their male counterparts, or as performing overtly sex-typed tasks such as sewing or typing. The concern is that failing to provide examples of girls or women performing interesting and varied actions or tasks limits the types of role models children are exposed to. Providing girls with different types of role models is important because there is a significant body of research that has found positive correlations between having same-sex role models and positive self-perceptions (Lockwood, 2006), educational attainment and aspirations (Beaman, Duflo, Pande & Taplova, 2012), sense of belonging in one's academic field (Rosenthal, Levy, London, Lobel, & Bazile, 2013), as well as positive implicit attitudes about, identification with, and increased effort for, one's chosen STEM field (Stout, Dasgupta, Hunsinger, & McManus, 2011).

Even though children are arguably exposed to fewer traditionally sex-typed stereotypes than they were nearly 50 years ago when the report from the Royal Commission on the Status of Women was released, sex and gender stereotypes surrounding STEM and the people in STEM still persist and are conveyed to children at a young age. As a test of the strength of science stereotypes, young children are often asked simply to draw a picture of a scientist. Many children draw a picture of a man with eyeglasses and a white a lab coat (Chambers, 1983). However there are interesting group differences in science stereotypes, with older students found to draw a higher number of stereotyped features than younger students, and male students more likely than female students to depict the scientist as male (Chambers, 1983). Results from these early studies suggest that STEM stereotypes, once learned, continue to persist as children age, as such stereotyped depictions of scientists have also been found among undergraduate students (Thomas, Henley, & Snell, 2006). Chambers' findings that male students are more likely than female students to draw a male scientist also indicates that science stereotypes are more pronounced for individuals who share common traits, such as sex, with the stereotype.

But where exactly do such stereotypes originate and where are there opportunities to expose children and youth to different types of role models? Among children whose parents come from non-STEM backgrounds, the only exposure to STEM models they might have comes from media such as games and television programming. In Canada today, many young children spend a significant amount of time in front of screens, consuming media in the form of television programs or video games. On average children age 3-4 spend 3.6 hours a day of screen-based sedentary behaviour, while 5-11 year olds spend 5.3 hours per day, and 12-17 year olds spend 5.8 hours per day (Active Healthy Kids Canada, 2013). With this amount of exposure to various kinds of media it is likely that children encounter various depictions of people in STEM, so it is important to understand how exposure to such depictions then shapes or influences children's STEM knowledge.

Research suggests there are relationships between the type of media consumed and the authenticity of depictions of scientists. For instance, children who rely on non-scientific media, such as video games, as inspirations for their drawing depictions of a scientist are more likely to draw less realistic portrayals of scientists than children who rely on more scientific sources such as books (Tan, Jocz, & Zhai, 2015). And among scientific and educational media there appears to be a disproportionate amount of programming that heavily or exclusively introduces male hosts, characters or narrators (Best Science Shows for Kids, n.d.; Bondar, 2011; Knapp, 2011; Nelson, 2013; Shaha, 2010; Shillinglaw, 2011). Children who spend a significant amount of time watching science programs that disproportionally show science and scientists as male pursuits may inadvertently adopt stereotypes accordingly.

In addition to media, children are likely exposed to STEM role models through their immediate family members. Parents appear to have a strong influence on career development of elementary school aged children, but this influence slowly diminishes as children get older (see review Whiston & Keller, 2004). Family dynamics can influence girls' career aspirations. For example, girls aged 7-11 who reported their mothers as having more decision making responsibilities in the family were also more likely to aspire to less feminine stereotyped careers (Lavine, 1982). Parents' own career paths have also been shown to influence girls' career development. Girls whose mothers worked in less female stereotyped careers reported aspiring to less stereotyped careers themselves (Selkow, 1984). One might suggest that this may be due to children simply mimicking a desire to follow the specific career paths of their parents, this does not appear to be the case. When asked, most first grade children (73%) can name a specific occupation they aspire to when they grow up, yet only half of these children are able to specifically name their mother or father's occupation (Auger, Blackhurst, & Wahl, 2005). These studies indicate young children, while influenced by their parent's career paths, do develop their own distinct career aspirations.

Teachers are strong role models for students, and it appears that teacher role models can be quite beneficial to students. One American study examined longitudinal data to compare a number of student outcomes, such as test scores, with instructor-student sex parings (Dee, 2007). It was found that same-sex pairings between student and instructor reduced the sex gaps in achievement in English and science for both boys and girls. In another study of a postsecondary institution that randomly assigned students to professors in a variety of mandatory courses, Carrell and colleagues (2009) found that while female students did not perform as well on average compared to male students in introductory math and science courses, the sex gap between male and female students was diminished when female students had female instructors, and this effect was strongest for students with high math ability.

Having a same-sex instructor has been positively correlated with students taking additional credits or majoring in some disciplines where their sex has been traditionally underrepresented, such as Education for male students or Geology for female students (Bettinger & Long, 2005). Further, female students are also found to be more likely to take additional geology, math or statistics courses if their initial class in those subjects was taught by a woman (Bettinger & Long, 2005). In addition to academic performance, female students who have female instructors are found to participate more in class and are more likely to seek help from their instructor than female students with male instructors (Stout et al., 2011). Such positive influence of same-sex role models is not limited to instructors; female students who interacted with a same-sex peer expert had more positive attitudes toward math, higher identification with math, and had increased effort for completing a math test than did female students who interacted with a male peer expert (Stout et al., 2011).

Such findings imply that female role models have a positive effect on girls and young women. There are a number of reasons why instructor sex might make a difference. Cognitive theories assume young children's understanding of sex and gender begins with recognizing and categorizing one's own and others' sex (see Martin, Ruble, & Szkrybalo, 2002). Children tend to learn this distinction very early in life and, for that reason, gender identity, the part of one's identity that draws upon cultural meanings of what it is to be male or female (Wood & Eagly, 2015), is a particularly salient trait for children to use to make social comparisons or to identify with other people. Social comparisons, or comparing oneself with another person, can in and of themselves have positive effects on the person making the comparison. Such upward social comparisons, comparing oneself to someone perceived to be superior in some way, can boost aspirations among those who are fairly confident in their abilities (Hoyt, 2013), perhaps due to their ability to perceive similarities between themselves and the person with whom they compare themselves.

Role models may also mitigate the effects of negative stereotypes. Women and minorities are found to perform much more poorly on tests and other tasks after negative stereotypes about one's group membership are primed, such as a encountering a stereotype that women are 'bad at math,' a phenomenon referred to as stereotype threat (see the meta-analysis by Nguyen & Ryan, 2008). Due to the persistence of stereotypes in STEM, stereotype threat has real implications for girls and women who might consider entering STEM fields. However, it seems the effects of negative stereotypes can be mitigated with appropriate role models. For example, sixth grade girls who read descriptions about a hardworking role model and the strategies the role model used in achieving success in math, performed as well as boys on a difficult math test, compared to girls who simply read descriptions about a person who succeeded due to being innately good at math (Bagès, Verniers, & Martinot, 2016). Same-sex role models are important for individuals whose group is a minority, such as being a woman in engineering, as having such role models can mitigate the effects of negative stereotypes by inoculating individuals against self-doubt, particularly in the early years of one's academic and processional development (Dasgupta, 2011). Indeed, in stereotype threat situations, such as being informed that male students perform better than female students in STEM courses, high school girls reported less concern about their own sex after selecting a hypothetical computing science course with a female instructor compared to students who selected a hypothetical course with a male instructor (Master, Cheryan, & Meltzoff, 2014).

Based on findings from previous research, in this study I ask the following research questions regarding possible influences of role models: Is there a relationship between having same-sex instructors and number of STEM courses taken? Is there a relationship between having same-sex instructors and pursuing a degree in STEM? Is there a relationship between the number of same-sex instructors and cGPA? Does personally knowing someone in a STEM field relate to STEM self-efficacy, number of STEM courses taken, and majoring/minoring in STEM? And finally, is there a correlation between the number of same-sex instructors and taking more courses in that field, or between declaring a major/minor in that field?

1.3. Self-Efficacy

Self-efficacy is defined as "people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). In other words, self-efficacy is a person's judgment about whether they are capable of performing an action or task that will lead to an expected outcome. Self-efficacy has been conceptualized as domain-specific (Bandura, 1977), meaning that one can have high self-efficacy in one domain, such as understanding and explaining biological processes, while having low self-efficacy in another domain, such as solving math problems.

Self-efficacy is an important phenomenon to consider in studying women's participation in STEM fields because it has been found to correlate strongly with a number of academic outcomes, such as persistence and perseverance (Britner &

Pajares, 2006), and achievement and educational aspiration (Novakovic & Fouad, 2013). These outcomes are of great interest to researchers who aim to better understand how to increase women's participation in fields that remain highly sex-segregated. Academic self-efficacy, confidence in one's overall ability to successfully perform academic tasks such as taking a test, is a strong predictor of achievement across multiple domains among middle school students (Lee, Lee, & Bong, 2014). The results are relatively mixed regarding whether there are sex differences in self-efficacy among STEM subjects. A number of sources report that girls have lower self-efficacy in areas such as mathematics and computing science (Huang, 2013; Lee, Lee, & Bong, 2014), reports that are noted across the globe. Among OECD countries, girls report lower self-efficacy than boys in mathematics and science although this difference is greater for mathematics and for tasks with sex-stereotyped content (OECD, 2015).

However, girls are not found to have low self-efficacy across all STEM fields; at least, findings are not always consistent. For example, Concannon and Barrow (2012) did not find sex differences in engineering self-efficacy. Instead, women were found to have lower coping self-efficacy and lower engineering career outcome expectations (Concannon & Barrow, 2012). These particular findings seem a contradiction. Why would women in engineering have lower career expectations in an area despite their relatively high self-efficacy? One implication of self-efficacy theory is that someone with lower self-efficacy will be more likely to quit when faced with difficulties. Perhaps women, who often report encountering academic and social obstacles as threats to their STEM career goals (Zeldin, Britner, & Pajares, 2008) and who may minimize their success in achieving high grades (Britner & Pajares, 2006), require relatively higher levels of self-efficacy than men to feel optimistic about pursuing a career in their field. Or, more generally, it is also possible there are sex differences in *why* people have high or low self-efficacy.

Self-efficacy is thought to derive from four main sources: mastery experiences (one's past performance), vicarious experiences (learning by observing others), social persuasion (verbal or nonverbal judgment of others), and physiological states (one's emotional state while performing an action; Bandura, 1986). There is some evidence to suggest there are sex differences in the relative influence of these sources (Britner &

Pajares, 2006; Sawtelle, Brewe, & Kramer 2012; Zeldin et al., 2008). For example, although girls in elementary and middle school (grades 5-8) receive higher grades in science than boys, girls do not report having higher overall self-efficacy, mastery experiences, or self-concept (Britner & Pajares, 2006). When grades are taken into account, girls appear to have lower self-efficacy and self-concept relative to boys. This implies girls may not be as sensitive as boys to environmental cues regarding what constitutes a mastery experience, an important finding because mastery experiences are often found to be most strongly correlated to overall science self-efficacy for both boys and girls (Britner & Pajares, 2006). Despite their higher relative performance, girls are clearly discounting their mastery experiences compared to boys or interpreting these experiences differently than boys.

Such differences in sources of self-efficacy were also described in a qualitative study comparing the academic and career experiences of men and women in STEM (Zeldin et al., 2008). Women in STEM very often referred to vicarious experiences and social persuasions as the most important factors that influenced their decisions to pursue STEM careers. In contrast, men were much more likely to talk about mastery experiences being important factors in deciding to go into STEM (Zeldin et al., 2008). This distinction is important because many self-efficacy measures rely on forced-choice type questions that may be biased toward reporting mastery experience over the other types of sources, and people may be less likely to remember comments they have received from others or previous observational experiences when they are completing a survey (Zeldin et al., 2008). When replying to open-ended interview questions women primarily recalled the important influence that peers, teachers, and social groups played in developing their confidence in STEM. In contrast, men were more likely to report those types of experiences aided the development of their confidence but they were not described as being of central importance.

1.3.1. Self-efficacy and Role Models

If women are relying on vicarious experiences and social persuasion, one might expect role models, and particularly same-sex role models with whom one can easily identify on the basis of ingroup identification, are likely to be a strong source of self-efficacy for female students. In support of this, female students do report feeling more confident in their STEM abilities when their instructor is a woman than they do when their instructor is a man (Stout et al., 2011). And female, as well as male participants, have reported higher academic self-efficacy after reading fictional bios of successful STEM female role models (Shin, Levy, & London, 2016).

However the link between role models and self-efficacy is not always clear. Cheryan and colleagues (2011) found no relationship between role model sex and self-efficacy in computer science. Rather, female students reported lower self-efficacy after interacting with a stereotypical role model regardless of the role models sex. Similarly Bagès, Verniers, and Martinot (2016) found no relationship between role model sex and female students' math test performance. In another study, researchers examined computer self-efficacy among American graduate and undergraduate students who reported having either a female or male mentor and found female students who had female mentors actually reported lower computer self-efficacy than female students with either a male mentor or both male and female mentors (Goh, Ogan, Ahuja, Herring, & Robinson, 2007).

With regard to the relationship between self-efficacy and role models, in this study I ask the following research questions: Do female students have lower self-efficacy in STEM than male students? Do the number of same-sex instructors and self-efficacy scores predict the number of STEM courses taken by female undergraduate students? Do the number of same-sex instructors and self-efficacy predict whether female students declare a STEM major?

1.3.2. Minority ethnic groups

There is a significant amount of research examining why fewer women enter STEM than men, yet there is far less literature considering both sex and ethnicity in STEM, which is problematic because there is evidence to suggest the experiences of women of colour may be unique in STEM. For example, during a 2-week science program for high-achieving girls in eighth grade, nonminority girls maintained high levels of science self-concept, interest and aspirations throughout the program while ethnic minority girls were found to have diminishing self-concept, interest and aspirations over time (Jayaratne, Thomas & Trautmann, 2003). The results from a longitudinal study in the United States (U.S.) examined the effects of a mentorship program on typically underrepresented STEM students and found that students with two minority statuses, in this case ethnicity and socioeconomic status, had lower scores on certain academic performance measures and self-efficacy than students who had only one minority status (MacPhee, Farro, & Canetto, 2013).

In the U.S., Black, Hispanic and Native American women have less representation in both academic and vocational areas of science and engineering than White or Asian women (National Science Foundation, National Center for Science and Engineering Statistics, 2015). Interestingly, Black and Hispanic men have been found to have greater representation in academic STEM fields compared to both White men and Black and Hispanic women (Riegle-Crumb & King, 2010), which suggests the experiences of some women of colour are quite different from those of men of colour or White women.

To better understand the influences of ethnicity and sex on participation in STEM, in an area with little pre-existing data, I will also examine what relationship exist, if any, between sex, ethnicity, academic course and degree choices, same-sex role models and self-efficacy.

Chapter 2.

Method

2.1. Participants

Participants were 249 Simon Fraser University undergraduate students enrolled in at least one STEM course in the fall 2014 semester. Students were recruited from a targeted email distributed via the University Student Services office in the middle of the fall 2014 semester. The email included a brief description of the study, the definition of the acronym STEM (i.e., science, technology, engineering and math), and an invitation to complete the online surveys. Three hundred and seventy students responded to the survey by clicking the url hyperlink provided in the body of the email directing them to the online survey. The online survey consisted of a student background questionnaire, an adapted Longitudinal Assessment of Engineering Self-Efficacy (LAESE), and a General Self-Efficacy questionnaire. Of the 370 students who responded, only 249 of these responses were complete enough for further data analysis (described in further detail below).

The average age of participants was just over 21, 58% of the participants were female, and on average participants were partway through their third year of study. One hundred and seventy five of the 249 students (70.3%) of students declared a STEM major. Descriptive statistics for scales describing participants' demographics are presented in Table 2.1. Table 2.2 displays frequencies for categorical information.

Table 2.1. Descriptive Statistics for Continuous Demographic Variables.

	Min	Max	M	SD
cGPA	0.00	4.33	2.30	1.43
Age	16	53	21.26	4.95
Year of Study at SFU	1	5	2.67	1.32

Note. n=249

Table 2.2. Descriptive Statistics for Categorical Demographic Variables.

	f	%
Sex	249	100
Male	103	41.4
Female	146	58.6
Ethnicity[a]	269[b]	100[c]
Aboriginal	4	1.48
European	135	50.18
Caribbean	1	.37
Oceania	1	.37
African	5	1.85
Arabic	26	9.66
Asian	92	34.20
Latin	5	1.85
Degree Field	249	100
STEM	175	70.28
non-STEM	74	18.87
Degree Type		
STEM Major	143	
STEM Minor	9	

Note. n=249

[a]Ethnic categories as defined by Statistics Canada.

[b]Frequency exceeds N due to multiple responses from some participants

[c]Percentages may not add to 100% due to rounding.

2.2. Procedure

Undergraduate STEM courses were first identified by the researcher as any course that was offered by a STEM (science, technology, engineering or math) department, or that was required for a Bachelor of Science (BSc) or Bachelor of Applied Science (BASc) degree. The researcher identified 310 STEM courses, and provided a list of these course offerings to the Student Services office for targeting potential study participants. Using this information, Student Services distributed an email to any undergraduate student enrolled in at least one of the identified STEM course. Due to the high volume of students who received the email study invitation (i.e., 11,809 students), and a higher than anticipated response rate, the survey website was briefly rendered inaccessible due to high web traffic. This may account for the somewhat high number of incomplete responses. Identifiable student numbers for the 250 complete respondents were provided to the Student Services office for further data extraction. Of these, 1 number could not be matched with information in the student database, thus resulting in 249 participants.

Data from the three online questionnaires were merged with data obtained from the University, after which identifiable student information (i.e., student numbers) was removed prior to the data analysis.

2.3. Treatment of Missing Data

For the purposes of the data analysis, all Likert scale responses of “Don’t Know” were treated as missing data and included in the analysis using pair-wise deletion.

2.4. Measures

2.4.1. Online Survey

The online survey contained a student background questionnaire (12 questions), a STEM self-efficacy measure (43 questions), and a general self-efficacy measure (10 questions). The survey completion rate was 68%, and the average time to complete the survey was 41 minutes.

Student Background Questionnaire

The student background questionnaire asked respondents to provide their age, sex, student number, ethnicity, number of STEM courses previously taken and level of courses (i.e., high school, college, university), sex of instructors for previously taken courses, how many of previously taken STEM courses had teaching assistants (TA's) or tutor markers (TM's), and sex of TA's and TM's, how many people the participant personally knows with a STEM degree or who works in a STEM field (see Appendix A).

STEM Self-Efficacy

The Longitudinal Assessment of Engineering Self-Efficacy (LAESE) was created via the Assessing Women and Men in Engineering Project (AWE, 2007) as an assessment of students' self-efficacy beliefs (Marra & Bogue, 2006; Marra, Moore, Schuurman, & Bogue, 2004). The LAESE utilizes a combination of a 7-point Likert scale to assess agreement to a series of statements (1=Strongly Disagree, 7=Strongly Agree), a 5-point Likert scale to indicate the importance of a series of statements (1=Very Unimportant, 5=Very Important), and a 5-point Likert scale to indicate their confidence about a series of statements (1=Not at all confident…, 5=Very confident…).

The original instrument contains 31 questions in total, representing six subscales (Career Success Expectations, Self-Efficacy I, Self-Efficacy II, Feelings of Inclusion, Coping Self-Efficacy, and Math Outcome Expectations). The first eight questions on the original instrument include two parts, inquiring about level of agreement and importance of a number of statements. Due to limitations of the online survey software these two parts were presented as sixteen separate questions instead of eight questions with two parts. This measure has been previously validated, but for the purposes of this study the instrument was adapted slightly to make it more specific to STEM in general. Modifications to the first subscale, Career Success Expectations (i.e., questions 17, 26, 28, 31, 34, 38, and 43) included changing the word 'engineering' to 'STEM' (e.g., *"A degree in STEM will allow me to obtain a job that I will like"*). One question from this subscale was removed (*I will succeed (earn an A or B) in my engineering courses*) to make the instrument less engineering-specific.

In the second subscale, Self-Efficacy I, questions 15 and 19 were similarly adapted to say 'STEM' instead of 'engineering'. Questions 21 and 22 (*I will succeed (earn an A or B) in my physics/math courses)* were changed to be less engineering specific, (i.e., *I will succeed (earn an A or B) in my lower/upper division courses*). This subscale assesses one's confidence to succeed in STEM curriculum or succeed in earning a high grade.

Changes to the third subscale, Self-Efficacy II (questions 24, 27, 29, 35, 40, and 44) included replacing the word 'engineering' with 'STEM' (e.g., *I can persist in a STEM major during the next year*). This subscale assesses one's confidence to complete specific STEM course or degree requirements.

All remaining subscales were unchanged.

General Self-efficacy

The general self-efficacy scale was developed by Schwarzer and Jerusalem (1995) to assess general perceived self-efficacy and adaptation to stressful life events. The instrument asks respondents to indicate the personal truthfulness of 10 statements as based on a 4-point Likert scale (1= Not at all true, 4=Exactly true).

2.4.2. University Data

Academic history and standing

For all 249 students who provided complete responses to the three online questionnaires, and who could be successfully matched to University records, the University provided additional information including courses (i.e., course number, title, and credit hours) transferred into, and taken at, SFU, letter grades for courses completed at SFU, cGPA, and declared major and minor.

Chapter 3.

Results

3.1. Research Questions

To address the first research question regarding whether men and women differ in course taking and degree declarations data were first checked for outliers or extreme values. No participant reported data were deemed extreme enough to warrant removal from the sample. Tests of normality revealed data about the number of STEM courses taken was non-normal, therefore a Mann-Whitney U test was used to compare men with women. Female students took fewer STEM courses (*M* 15.32, *SD* 12.30) than male students (*M* 20.18 *SD* 13.49), and this difference was statistically detectable (U= 5772, p = .002).

To investigate whether female and male students differed in likelihood of declaring a STEM major or minor, a chi square test of independence was performed. A small yet statistically detectable relationship between sex and STEM major, $x^2(1)=5.32$, $p=.021$, was found. A similar chi square analysis between sex and STEM minor was not possible due to the expected counts ≤ 5 exceeding 20%, but this relationship was deemed to be not statistically detectable using Fisher's Exact Test (df=1, p=.62).

Next, males' and females' cumulative grade point average (cGPA) were compared. Scores for male (*M* 2.27 *SD* 1.45) and female students (*M* 2.36 *SD* 1.41) met assumptions to proceed with an independent samples *t*-test. No statistically detectable difference was observed, t (247) = -.52, p >.05, two-tailed, (*MD*=-.095, *SED*=.18), 95% *CI* [-.45, .26], U= 7289, p >.05.

3.1.1. Role Models

Next the research questions regarding role models were examined. Overall respondents reported having had more male STEM instructors (*M* 10.28 *SD* 6.19) than female STEM instructors (*M* 6.16 *SD* 3.96). A Pearson correlation coefficient described the relationship between the number of reported same-sex instructors and the number of STEM courses taken. Same-sex Instructor, was calculated based on participants' reports of instructor sex. For female students the same-sex Instructor variable equaled the number of female instructors they reported; for male students same-sex Instructor equaled the number of male instructors they reported. Due to non-normal distribution of the data, new variables for the number of STEM courses taken and number of same-sex Instructor were computed using the square root transformation. For female students, r = .48, n=146, p <.01, and for male students, r = .72, n=100, p <.01, same-sex instructors were moderately to strongly correlated with the number of STEM courses taken.

To determine if there was a relationship between instructor sex and declaring a STEM major, a point biserial correlation was computed between the number of female instructors and STEM major. For females this correlation was statistically detectable, r_{pb}=.312 (n=146, p=.003), and for males it was not, r_{pb}=.216 (n=81, p=.053). A point biserial correlation was also used to examine the correlation between Same-sex Instructor and declaring a STEM major, and statistically detectable positive relationships were found for both male and female students (Table 3.1).

Table 3.1. Point Biserial Correlation Between Same-Sex Instructors and Declaring a STEM Major.

	Male Students			Female Students		
Variable	M	SD		M	SD	
Same-Sex Instructors	3.17	1.03		2.31	.89	
STEM Major	.90	.30		.77	.42	
r_{pb}			.38**			.33**

**p<.01

Next I examined student responses regarding how many people they personally knew who had a STEM degree or who worked in a STEM field. Both male and female students reported knowing more men than women with a STEM degree or working in a STEM field (Table 3.2).

Table 3.2. Descriptive Statistics for Number of Social Connections (SC) With a STEM Degree or Career.

	M	SD
Female Students (*n*=146)		
Female SC with STEM Degree	1.34	1.18
Male SC with STEM Degree	1.75	1.26
Female SC with STEM Career	.96	1.04
Male SC with STEM Career	1.47	1.24
Male Students (*n*=103)		
Female SC with STEM Degree	1.16	1.23
Male SC with STEM Degree	1.80	1.12
Female SC with STEM Career	.86	.99
Male SC with STEM Career	1.49	1.09

A Pearson correlation was computed between the total number of same-sex individuals with a STEM degree or career in one’s social network and the number of STEM courses taken. For female students there was no detectable correlation between the two variables, $r = .12$, $n=146$, $p>.05$; for male students there was a small to medium correlation $r = .33$, $n=$, $p<.05$.

3.1.2. Self-efficacy

The subscale scores from the LAESE were examined and transformed to z scores, and one score exceeding ± 3.29 was removed prior to analysis. Descriptive information on the LAESE subscales and GSE scores are presented in Table 3.3.

Table 3.3. Descriptive Statistics for Dependent Measures.

	Male			Female		
	N	M	SD	N	M	SD
LAESE Career Success Subscale	103	4.39	1.21	145	4.16	1.18
LAESE Self Efficacy I Subscale	103	4.27	1.26	146	3.97	1.27
LAESE Self Efficacy II Subscale	103	4.47	1.28	146	4.08	1.32
LAESE Inclusion Subscale	103	3.95	1.14	146	3.71	1.24
LAESE Coping Subscale	102	4.67	.81	145	4.54	.80
LAESE Math Outcome Subscale	99	4.15	1.49	144	3.83	1.37
General Academic Confidence	102	3.42	.82	145	3.07	.94
General Self Efficacy	103	3.17	.44	146	3.11	.43

The relationship between sex and the LAESE subscales (self-efficacy, career expectations, feelings of inclusion, coping self-efficacy, math outcome expectations) was further examined using Pearson correlation. Results are displayed in Table 3.4. Statistically non-zero Pearson r correlations were observed between student sex and the LAESE subscale Self-Efficacy II ($p<.05$) and General Academic Confidence ($p<.01$).

A multivariate analysis of variance (MANOVA) was computed with the independent variable Sex and dependent variables Self-Efficacy II and General Academic Confidence. This revealed a statistically detectable difference between sex and dependent measures (Wilks λ, $F[2,244] = 4.99$, $p<.01$, partial $n^2=.04$). Univariate ANOVA’s found statistically different results between sex for both dependent measures (Table 3.5).

Table 3.4. Pearson Correlations Among Student Sex and LAESE Subscale Scores.

		1	2	3	4	5	6	7	8	9
1.	Sex	-								
2.	Career Expectations	.09	-							
3.	STEM Self-Efficacy I	.12	.48**	-						
4.	STEM Self-Efficacy II	.15*	.64**	.55**	-					
5.	Feeling of Inclusion	.10	.44**	.42**	.31**	-				
6.	Coping Self-Efficacy	.08	.46**	.27**	.39**	.34**	-			
7.	Math Outcome Expectations	.11	.35**	.27**	.31**	.16*	.17**	-		
8.	General Academic Confidence	.19**	.45**	.32**	.60**	.29**	.24**	.09	-	
9.	General Self-Efficacy	.07	.30**	.32**	.22**	.20**	.38**	.14*	.16*	-

*p<.05
**p<.01

Table 3.5. Multivariate and Univariate Analysis of Variance for Self-Efficacy and General Academic Confidence.

	Multivariate		*Univariate*	
	df	F^a	*Self-Efficacy II*^{b}	*General Academic Confidence*^{b}
F ratios for sex	2	4.99	6.17*	9.28**
MSE			10.35	7.41

Note: Multivariate F ratios were generated from Wilk's criterion.
a. Multivariate df = 2, 244
b. Univariate df = 1, 245
*p <.05; **p<.01

To determine if the number of same-sex instructors and self-efficacy predicted the number of STEM courses taken, multiple linear regression stepwise analyses were computed for women and men with the dependent variable Number of STEM Courses

Taken and the independent variables Same-sex Instructor, the LAESE subscales and GSE scores. For female students the variables General Academic Confidence (ß = .37) and Same-sex Instructor (ß = .39) were statistically detectable predictors of the number of STEM courses taken (F(2,139) = 42.53, p<.000), R^2= .38. For male students the variable Same-sex Instructor (ß = .69) and Self-Efficacy I (ß = .16) were the statistically detectable predictors of the Number of STEM Courses Taken (F(2,92) = 46.74, p<.000), R^2=.49 (Table 3.6).

Table 3.6. Multiple Linear Regression Analyses for Number of STEM Courses Taken, Same-Sex Instructors, LAESE Subscales and GSE (N=237).

	Male Students			Female Students		
	B	*SE B*	*β*	*B*	*SE B*	*β*
Self-Efficacy I	1.76	.81	.16*	-	-	-
Same-Sex Instructors	1.42	.15	.69**	1.24	.22	.39**
General Academic Confidence	-	-	-	4.96	.92	.38**
R^2			.48			.37
F			46.74			42.53

*p<.05
**p<.01

To address whether the variables Same-sex Instructor and Self-Efficacy predict being a STEM major, a logistic regression was conducted using the categorical dependent variable Major Type and the independent variables Same-sex Instructors, LAESE subscales and GSE scores. Results indicated the model was statistically detectable: for female students x^2(9, N =146) = 47.63, p <.01; for male students x^2(9, N = 103) = 35.07, p <.01. The Nagelkerke R^2 indicated that the model accounted for 66% of the total variance for females and 76% of the total variance for males. Correct prediction rates were relatively high, 97% for female STEM majors and 61% for female non-STEM majors. Table 3.7 presents the regression coefficients (B), the Wald statistics, type I error rate, odds ratio [Exp(B)], and the 95% confidence intervals (CI) for odds ratios (OR) for each predictor.

Table 3.7. Logistic Regression Results for Predicting STEM Major According to Same-Sex Instructor, LAESE Subscales and GSE – Female (Male).

					95% CI	
Step	Variable Entered	B	Wald	Exp(B)	Lower	Upper
1	Career Expectations	.79 (-.12)	2.44 (.01)	2.21 (.89)	.82 (.04)	5.9 (21.95)
1	STEM Self-Efficacy I	-1.40 (-.35)	7.24** (.15)	.25 (.71)	.09 (.12)	.68 (4.22)
1	STEM Self-Efficacy II	1.50 (1.92)	4.91* (1.51)	4.49 (6.83)	1.19 (.32)	16.93 (145.74)
1	Feeling of Inclusion	.61 (.35)	2.40 (.19)	1.84 (1.42)	.85 (.29)	3.99 (7.11)
1	Coping Self-Efficacy	-.09 (-1.84)	.01 (1.31)	.92 (.25)	.20 (.01)	4.23 (3.72)
1	Math Outcome Expectations	.22 (.23)	.25 (.09)	1.25 (1.26)	.53 (.27)	2.94 (5.84)
1	General Academic Confidence	1.16 (2.12)	2.18 (3.37)	3.20 (8.35)	.68 (.87)	15.05 (80.70)
1	General Self-Efficacy	-2.51 (-4.62)	3.85* (1.33*)	.08 (.01)	.01 (.000)	1.0 (25.63)
1	Same-sex Instructor	.15 (.26)	1.43 (1.15)	1.16 (.28)	.91 (.81)	1.47 (2.08)

N=249
*p<.05
**p<.01

3.1.3. Ethnic Minorities

Research suggests ethnic minority students may have lower scores on some measures of academic performance and self-efficacy. To explore this issue, self-efficacy was examined within the context of sex and ethnicity. In this sample, 55% of female students reported belonging to a minority ethnic group (Aboriginal, European, Caribbean, Oceanic, African, Arabic, Asian, or Latin), as did 51% of male students. Descriptive statistics about cGPA and ethnicity are included in Table 3.8.

Table 3.8. Mean cGPA for Ethnic Minority and Nonminority Students.

	M	SD
Female Ethnic Nonminority (*n*=66)	2.57	1.40
Female Ethnic Minority (*n*=80)	2.02	1.45
Male Ethnic Nonminority (*n*=53)	2.71	1.20
Male Ethnic Minority (*n*=53)	2.03	1.53

N=246

To investigate differences between female students who identify with a minority ethnic status and female ethnic majority students' course-taking behaviours, a Mann-Whitney U test was used to compare the group means. Results revealed no statistically significant difference in the number of STEM courses taken by female ethnic majority students (*M* 16.53, *SD* 13.34) compared to ethnic minority female students (*M* 14.31 *SD* 11.37; *U*= 2405, *p*>.05).

To determine whether ethnic minority female students had lower academic achievement, an independent samples t-test compared cGPA for Ethnicity majority/minority status (coded as 1=majority, 0=ethnic minority). There was a statistically detectable difference, *t*(144)=-2.34, *p*<.05, two tailed, (*MD*=-.56, *SED*=.24), 95% CI [-1.02, -.09], (U=5673.5, p < .01), Cohen's *d* =.39 indicates a moderate effect size. Female students with ethnic minority status had significantly lower cGPA (*M*=2.02, SD=.16) than females who were not (*M*=2.57, *SD*=.1.40).

To investigate whether ethnic minority female students were less likely to declare a major or minor, chi square test of independence were performed. Results indicated non-detectable findings for both ethnic minority status and STEM Major (x^2*(1)=.71, p>.05*) and for STEM Minor (x^2*(1)=3.09, p>.05*).

Role Models

A factorial analysis of variance (ANOVA) was conducted to assess the relationship between number of same-sex instructors and the number of STEM courses taken for ethnic minority students. No statistically detectable main effect was found between same-sex instructors and ethnicity for female students (*F*(14,114) = .60, *p*>.05).

A factorial ANOVA was then conducted to assess the relationship between minority ethnicity, the number of reported same-sex social connections with the dependent variable number of STEM courses taken. No statistically significant main effect was found between same-sex social connections and ethnicity for female students (*F*(7,128) = 1.63, *p*>.05).

Self-Efficacy

Within female students, relationships among sex, ethnicity and STEM self-efficacy (i.e., LAESE subscales: self-efficacy, career expectations, feelings of inclusion, coping self-efficacy, math outcome expectations) were examined using Pearson correlation (Table 3.9). A statistically detectable correlation was found between female ethnicity and General Self-efficacy (p<.01) and between ethnicity and General Academic Self-Confidence (p<.05).

Table 3.9. Pearson Correlations Among Female Student Ethnicity and Self-Efficacy Scores.

		1	2	3	4	5	6	7	8	9
1.	Ethnicity	-								
2.	Career Expectations	.14	-							
3.	STEM Self-Efficacy I	.06	.47**	-						
4.	STEM Self-Efficacy II	.06	.58**	.55**	-					
5.	Feeling of Inclusion	-.03	.44**	.40**	.34**	-				
6.	Coping Self-Efficacy	.05	.47**	.35**	.40**	.46**	-			
7.	Math Outcome Expectations	-.11	.28**	.27**	.31**	.14	.15	-		
8.	General Academic Confidence	.19*	.47**	.30**	.67**	.32**	.20*	.08	-	
9.	General Self-Efficacy	.25**	.22**	.23**	.15	.07	.27**	.13	.10	-

*p<.05
**p<.01

To determine if differences exist between ethnic minority and non-minority students, a multivariate analysis of variance (MANOVA) was calculated with the independent variable Ethnicity and dependent variables General Self-Efficacy and General Academic Confidence. A statistically detectable difference was observed between ethnicity and dependent measures (Wilks λ, F[2,142] = 6.86, p<.01, partial

n^2=.09). Univariate ANOVA's showed statistically detectable effects of ethnicity for both dependent measures, as shown in Table 3.10.

Table 3.10. Multivariate and Univariate Analysis of Variance for General Self-Efficacy and General Academic Confidence.

	Multivariate		*Univariate*	
	df	F^a	*General Self-Efficacy*[b]	*General Academic Confidence*[b]
F ratios for ethnicity	2	6.86	9.25**	5.31*
MSE			1.63	4.57

Note: Multivariate F ratios were generated from Wilk's criterion.

a. Multivariate df = 2, 142

b. Univariate df = 1, 143

**p* <.05; ***p*<.01

Chapter 4.

Discussion

Participants in this study were recruited based on their enrollment in at least one STEM class during the semester of data collection. Existing research has found female students in Canada are less likely to declare a STEM major (Department of Finance Canada, 2014; Statistics Canada, 2013), and the results from this sample of undergraduate students support existing research that finds female students take fewer STEM courses and are less likely to have a declared STEM major than male students. Given that females are less likely to pursue a STEM major, it is understandable that they would then take fewer STEM courses, since individuals pursuing a STEM major would be required to complete more STEM courses to fulfill their degree requirements.

For both male and female students a correlation was found between the number of same-sex STEM instructors and being a declared STEM major. This finding is consistent with the theory that students will pursue degrees in disciplines where the instructors are perceived to be similar to them. And indeed the proportions of female instructors are highest in disciplines with a higher number of female students, such as the humanities and education (Simon Fraser University, 2016).

There was no detectable relationship between pursuing STEM and the number of same-sex role models within one’s social circle. However, among male students, there was a small to medium correlation between the number of same-sex role models and pursuing STEM. This relationship is consistent with the fact that male students on average reported knowing more individuals of the same sex who had a STEM degree *and* STEM career, whereas female students reported on average far fewer same-sex individuals who had both a STEM degree and career. One interpretation is that female students may be somewhat deterred from pursing fields of study for which they do not anticipate future career opportunities. Or it is also possible that, as Drury, Siy and Cheryan (2011) propose, role model sex does not influence STEM recruitment and so the sex of one's social connections would not influence whether or not one enters STEM.

Results from the LAESE revealed female students had lower average scores than male students on each of the subscales: Career Success, Self-Efficacy I and II, Inclusion, Coping, Math Outcome, General Academic Confidence, and General Self-Efficacy. However, only the subscales Self-Efficacy II and General Academic Confidence revealed a detectable statistically significant correlation with participant sex, supporting past research that shows female students have lower self-efficacy for STEM than male students (Huang, 2013; Lee, Lee, & Bong, 2014; OECD, 2015).

Female students' General Academic Confidence and the number of same-sex instructors were both statistical predictors of the number of STEM courses taken, while for male students the number of same-sex instructors and Self-Efficacy I were detected as predictors of the number of STEM courses taken. This contrasts to other research findings that report no correlation between role model sex and success beliefs (i.e., self-efficacy; Cheryan, Siy, Vichayapai, Drury, & Kim, 2011). According to the logistic regression model in the current study, the odds of being a STEM major were more than 4 times greater for female students with high STEM self-efficacy. The odds of being a STEM major were also slightly greater for female students with high general self-efficacy.

These results indicate that among female undergraduates there is a relationship between STEM self-efficacy and the number of same-sex instructor and pursuing STEM. Female students who reported a higher number of female instructors were more likely to take STEM courses and further, general confidence and self-efficacy were predictors of female students' number of STEM courses and declaring a STEM degree. These findings are important because they highlight a number of areas where changes might be made to encourage more female students to pursue STEM.

First, the fact that both male and female students reported having far fewer female instructors in STEM highlights a possible need to address representation among female postsecondary instructors. Among SFU departments where female undergraduates are least represented, SFU female faculty themselves only comprise approximately 26% of science instructors, 21% of engineering faculty and fewer than 20% in applied science, physics, computing science and mechatronics engineering (Simon Fraser University, 2016). There is evidence to suggest that although female faculty are hired at lower rates across a range of disciplines, retention rates remain the same for both men and women (Kaminski & Geisler, 2012). This supports an interpretation that increasing hiring rates of female faculty might be effective at sustaining sex representation among faculty.

Second, if women rely more than men on social persuasion as a source of self-efficacy (Zeldin et al., 2008), and academic confidence and self-efficacy are related to female students' pursuing STEM degrees, female students in particular may benefit from female instructor-student STEM mentorship programs. Mentorship programs have been found to improve a number of academic outcomes such as increased academic performance (Bayer, Grossman, & DuBois, 2013). And, because female students have reported being more satisfied with longer mentoring relationships than male students (Rhodes, Lowe, Litchfield, & Walsh-Samp, 2008), providing such opportunities early in students' studies might be beneficial.

There are limitations on generalizing these results to a broader population. First, the LAESE scale did not allow separating the influence of the four theorized sources of self-efficacy (mastery experiences, vicarious experiences, social persuasion, and physiological states). This could be important to consider when examining the relationship between STEM pursuance and the influence of role models.

In addition, there are few standardized or validated measure for assessing role model influences and relationships and, in much of the research, students are simply asked to report about their role models. This relies too heavily on students' interpretations of the definition of role model. In this study, it was assumed that students would consider their instructors and close family to be role models. However, this assumption may not necessarily hold true for every student.

This study also generalized participant responses in terms of the overarching concept of STEM rather than with regard to specific STEM faculties or departments. By doing so, it is difficult to identify student characteristics for each discipline. Female students are not underrepresented equally among all STEM fields. The approach to assess the broader term STEM may have limited the depth of the findings.

Finally, research questions addressed using correlational analyses mean that causal interpretations of the statistical results cannot be made. It is possible the correlations between female students degrees and number of same-sex instructors are due by a third factor unrelated to student or instructor sex.

4.1. Future Directions

Nationally, and at SFU, there are many fewer male students enrolled in a number of non-STEM areas, such as social sciences and education (Simon Fraser University, 2016; Statistics Canada, 2016). Future research would benefit from examining possible factors that contribute to male student's lower enrollment in these areas, to identify commonalities or differences between male's non-STEM and female's STEM underrepresentation.

A significant amount of research into women's underrepresentation in STEM tends to treat sex as a homogenous variable when there is evidence the experience of girls and women belonging to U.S. ethnic minorities may be unique in STEM (Jayaratne, Thomas & Trautmann, 2003; MacPhee, Farro, & Canetto, 2013; National Science Foundation, National Center for Science and Engineering Statistics, 2015; Riegle-Crumb & King, 2010). There is little Canadian research regarding women's underrepresentation in STEM and the intersection of sex and ethnicity, and in this study approximately half of the students identified themselves as an ethnic minority. Although this study found no statistically detectable differences between female ethnic minority and majority students with regard to likelihood of majoring in STEM or in STEM self-efficacy, results from the pre-existing literature suggest this warrants further exploration.

Research regarding women's representation in STEM would also benefit from further examining possible influences of the type and quantity of media presenting science topics that children consume, as children develop gendered stereotypes about science at quite a young age (Chambers, 1983). There have recently been a number of controversies regarding consumer items, such as books or clothing, designed for young girls that promote anti-intellectual stereotypes about women (Bell, 2011; McKissick, 2013; NPR Staff, 2014). Future research might further examine ways in which heavily gendered advertising influences STEM stereotypes.

Although women are presently underrepresented in a number of STEM disciplines for a variety of reasons, we can look to policies implemented at institutions in the U.S. that have significantly boosted the number of female students in traditionally male disciplines such as computing science or engineering. For example, Harvey Mudd College in Claremont, California, has increased the number of female students graduating from computing science from 12 percent to 40 percent in just five years (Corbett & Hill, 2015). This impressive increase is the result of three substantial changes to the curriculum: "revising the introductory computing course and splitting it into two levels divided by experience, providing research opportunities for undergraduates after their first year in college, and taking female students to the Grace Hopper Celebration of Women in Computing Science" (Corbett & Hill, 2015, p. 4).

Using a similar approach that emphasizes framing problems in a real-world context and providing female students with opportunities to gain skills and experience, the Thayer School of Engineering at Dartmouth has recently increased the number of female engineering majors from a school average of 30 percent to 50 percent for the 2016 graduating class (Fiorentino, 2015). Thayer allows students to modify their major by incorporating Liberal Arts courses into their engineering degrees, an option that appeals to many students, particularly women (Fiorentino, 2015).

Among engineering schools in Canada, the University of British Columbia (UBC) has focused recruitment efforts toward women and currently nearly 30 percent of those enrolled in engineering are women (University of British Columbia, Public Affairs, 2015). The University of Toronto (U of T) has made concerted efforts to increase outreach to improve women's representation in its engineering faculty. This has boosted the enrollment of female engineering students to 30 percent, In the 2014-2015 academic year, three out of four newly hired engineering faculty were women, and three of the faculty's current research chairs are women (University of Toronto, Engineering Strategic Communications, 2015). Both these institutions' enrollment figures are relatively higher than the national average, where only 20 percent of undergraduate engineering students are women (Statistics Canada, 2016).

Clearly there is much to be done to continue improving women's representation in STEM fields that have been traditionally considered male domains. Results of policy changes in a number of postsecondary institutions reveal that boosting women's confidence, by providing them with real-world experience during their studies, *and* providing women with relevant female role models, either by increasing the proportion of female faculty or attending female-focused conferences, can have very real impacts on women's STEM participation.

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