Combating the Chilly Climate of the Sciences: Examining the Efficacy of All-Girls Schools in Increasing Female Participation in STEM

By

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Abstract

Over the last several decades, female students’ interest, participation, and achievement levels in STEM (science, technology, engineering, and mathematics) have been on the rise. However, there is still a significant gender gap in education. My qualitative research study investigates the reasons as to why female students perform better in all-girls learning environments. The purpose of my study is to answer the following overall research question by interviewing four mathematics and science teachers from two different all-girls schools in the Greater Toronto Area: “How are all girls schools effective in stimulating girls' interest, participation, and self-confidence in non-traditional fields of study?”
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Chapter One: Introduction

Introduction to the Research Study

Over the last forty years, female students’ interest and participation in non-traditional fields of study have been on the rise (Hembrow-Beach, 2011). Non-traditional fields of study are male-dominant and include but are not limited to the sciences, information technology, engineering, and mathematics (STEM). However, despite the fact that women have made significant gains in these areas, a significant gender gap in education still exists as women continue to be underrepresented in these fields (Hembrow-Beach, 2011). This begins in early elementary school and percolates the workforce as a result of a variety of factors, particularly the negative effects of stereotype threat (the fear of reifying negative stereotypes attributed to one’s own group of people, such as the stereotype that girls are not good at math) as perpetuated by male parents, teachers, and male peers within school settings. In this study, I investigate these phenomena through interviews with four mathematics and science teachers from two different all-girls schools in the Greater Toronto Area and a review and application of relevant literature.

Purpose of the Study

Anderson and Gilbride (2007) state, “there is a general perception that girls fare better in math and science in all-girl environments” (p. 5). This study is intended to investigate this notion through researching the efficacy of all-girls schools in comparison with co-educational schools in stimulating girls' interest, participation, and self-
confidence in STEM. Specifically, this study will examine both local and global research findings about the overall efficacy of all-girls learning environments, compare findings from girls’ attitudes, participation, and achievements in all-girls versus co-educational schools, and identify strategies that are proven to help stimulate girls’ involvement in STEM. This is important to the educational community because recent studies show that female students make up over half of the overall university population, yet less then a quarter of female students are enrolled in non-traditional fields such as engineering (Anderson and Gilbride, 2007, p. 1).

**Research Questions**

The ultimate goal of this research study is to determine what makes all-girls learning environments effective. Specifically, this study aims to answer the following research question: *How are all-girls schools effective in stimulating girls' interest, participation, and self-confidence in STEM?* Moreover, this research study is intended to address the following subsequent questions stemming from the aforementioned overall research question: *How are women presently represented in non-traditional fields of study? What are the effects of all-girls versus co-educational learning environments on female STEM students? What are some effective strategies for increasing female students’ involvement in non-traditional subjects? And how does the stereotype threat affect female students in STEM classrooms?*

**Background of the Researcher**

The decision to conduct my research study on the efficacy of all-girls schools on helping female students combat the chilly climate of the sciences is based on my own educational background. I attended an all-girls high school and feel that my educational experience throughout my secondary school years played a positive and significant role in my personal and academic development. Although I did not personally pursue a career
in STEM, I went on to complete my undergraduate degree with a major in Women and Gender Studies at the University of Toronto, where I gained valuable insight about the gender gap that was so prominent historically and that continues to permeate the educational community today. As a teacher, it is my desire to learn about strategies that I can use in my future classroom that will help narrow this gender gap in STEM education.

Overview

This research paper is comprised of five chapters. Chapter One contains an introduction to the research study. In it, I indicate the purpose of the study, main and subsequent research questions, and information about as my background as a researcher. In Chapter Two, I provide a literature review of established research findings on the same topic. In Chapter Three, I explain the methods and procedures that I used in this study including information about the research participants and data collection instruments. In Chapter Four, I state all the findings of my research study and their connections to the literature review. Finally, in Chapter Five I provide a discussion of the findings, which include the implications of my research, recommendations, further connections to the literature review, limitations I encountered, and suggestions for future study. References and a list of appendixes follow at the end.
Chapter Two: Literature Review

There has not been very much research conducted on the efficacy of all-girls schools in relation to female students’ interest, participation, and self-confidence in non-traditional fields of study. For the purpose of supporting this research study, the topics presented in the literature review will address the recent trends in representation of women in STEM and will share information pertaining to the efficacy of all-girls learning environments. Furthermore, strategies for increasing female interest in STEM will be shown. Finally, the negative effects of stereotype threat and the differential treatment of girls will be addressed. The information presented in the literature is drawn from studies conducted in Canada as well as internationally.

Underrepresentation of Women in Non-Traditional Fields of Study

Hembrow-Beach (2011) explains that female students’ test scores in the fields of math and science have been rising drastically since the 1980s; however, female students’ enrollment numbers in math and science courses has still not matched that of their male peers. (p. 4) These fields are socially regarded as predominantly male, and are therefore seen as non-traditional fields for women. Anderson and Gilbride (2007) explain that female university students in Canada represent less than twenty-five percent of students enrolled nationally in engineering programs, even though they make up more than fifty percent of the overall university population. (p. 1) Their Toronto-based qualitative research study of both co-educational and all-girls female high school students’ knowledge of and attitudes toward engineering shows that girls are just as aware of engineering as a discipline as their male counterparts; however, female students are significantly less interested than male students in pursuing careers in this field. (p. 1)
Anderson and Gilbride (2007) also explain that there are several documented reasons for girls not choosing engineering as a career. Reasons include low self-confidence in the teenage years, the masculine image of engineering, negative attitudes about male peers, the lack of strong female role models, the lack of course preparation, narrow course material, streaming out of basic math and science, the stress and isolation of being a minority, and concerns about balancing a demanding career with having a family. (p. 1)

In regards to female interest and participation in the field of information technology, Peckham (2009) states that increasing female enrollment numbers is a perpetual challenge for many technology educators, and that girls usually shy away from taking technology courses even when they seem to be interested in learning technology-based skills. (p. 14)

The Efficacy of All-Girls Learning Environments

Through their research study on the efficacy of a high school outreach program on increasing female interest in engineering, Anderson and Gilbride (2007) found that in comparison to only 18% of female students at co-educational schools, 31% of students at all-girls schools became more interested in engineering after participating in the Discover Engineering outreach program. (p. 6) These results show that all-girls learning environments are effective in elevating female students’ interest levels in non-traditional fields, such as engineering. (p. 7)

In regards to girls’ motivation and achievement in the sciences and mathematics, Picho and Stephens (2012) state that studies have shown all-girls schools are effective in having strong positive effects on girls’ self-conceptions and overall achievements in the
physical science domains. (p. 54) They also explain that, on average, students at all-girls schools score higher than girls at co-educational schools on standardized tests in non-traditional fields of study. (p. 54)

Picho and Stephens (2012) cite multiple studies that support the assertion that all-girls schools have positive effects on girls’ interest and performance in the maths and sciences. For instance, they refer to Carpenter and Hayden’s (1987) comparative study of girls in Australian co-educational versus single-sex schools, the results of which show students from the all-girls school “identified more strongly with the sciences and were more inclined to pursue these subjects at the high school level compared with those girls in co-educational schools.” (p. 54)

Picho and Stevens (2012), also refer to a study conducted by Gillibrand et al. (1999) in which the impact of girl’s-only classes in co-educational schools was assessed. Results show that female physics students in single-sex classes experienced improvements in physics identification and efficacy in comparison to female students in co-educational classes. (p. 54) The 1999 study also showed that students from the all-girls classes outperformed their co-educational peers on the British standardized achievement test in physics. (p. 54)

The results of Picho and Stephens’ (2012) own qualitative study on school differences in mathematics motivation and performance among Ugandan female high school students show that their hypothesis was supported by the findings. (p. 56) Findings show that girls from the single-sex school reported significantly higher MAT scores as well as higher levels of mathematics identification and self-efficacy in comparison to those reported by girls from the co-educational school. (p. 54)
As Hembrow-Beach (2011) states, “Studies also show that girls benefit from single-sex education, both in academics and in how they perceive their educational experience.” (p. 4). Girls’ perceptions of their educational experiences are highly important because education and socialization in terms of social-emotional learning and development often take place at schools; however, most co-educational school settings fail to provide girls with the support they need to thrive in these aspects. (p. 11)

Hembrow-Beach (2011) refers to a study conducted by the National Coalition of Girls Schools (2005) in which alumnae of all-girls schools were polled to report on how they perceived their education in single-sex learning environments. (Hembrow-Beach, 2011, p. 13) Overall, the majority of participants reported that their all-girls learning experiences provided them with “superior opportunities to engage in public speaking, technology, science, math and writing” in comparison to the experiences of their peers growing up in co-educational schools. (p. 13)

Hembrow-Beach (2011) also refers to a study by Van de Gaer et al. (2004) on Belgian middle school students, whereby the effects of all-girls schools and all-girls classes within co-educational schools were examined in terms of their students’ overall scores in mathematics. Findings from this study show that students from all-girls schools had higher achievement levels in mathematics in comparison to girls from co-educational schools. (Hembrow-Beach, 2011, p. 16) Findings from the same study also show that the students from the all-girls schools even outperformed students from the all-girls classes within co-educational schools. (Hembrow-Beach, 2011, p. 16) Overall, studies consistently show that the overall efficacy of all-girls schools is high and that “being in an all female educational institution prove[s] to be most beneficial to [girls’] academic achievement.” (p. 17)
Strategies for Increasing Female Interest in Non-Traditional Fields

Accessibility to hands-on learning programs

Participation in hands-on high school outreach programs such as Discover Engineering, an all-girls engineering outreach program aimed at increasing female students’ interest in and knowledge of the field, have been found to significantly increase interest among female students in pursuing engineering as a career (Anderson and Gilbride, 2007, p. 7). In a research study conducted on students from an all-girls high school, Rutz and Shafer (2011) report that the case study approach is effective in engaging female students in non-traditional fields such as engineering. (p. 26) Rutz and Shafer (2011) explain that through the case study methodology, students were able to participate in a hands-on engineering learning experience whereby they were able to tour a power plant, conduct individual and group research, and work as part of a team to devise a solution to a problem presented. (p. 26) Findings from the study indicate that participants showed significant improvements in their cognitive skills, their attitudes toward engineering, and their team working skills as a direct result of engaging in the case study method of learning. (p. 33)

Female representation in course content

In order to help encourage female involvement in the field of information technology, researchers Silverman and Pritchard (1996) suggest that teachers arrange to have women in technology-related careers come to their classes as guest speakers. (p. 15). Silverman and Pritchard (1996) also suggest that schools use resources that display pictures showing both males and females in technology-related fields. Finally, Silverman and Pritchard (1996) recommend that schools organize forums where female technology
students can engage in conversations with prospective students who are considering options for high school elective courses. (p. 15).

**Offering single-sex classes**

Peckham (2009) explains that female students at Clearwater High School in Clearwater, KS often seemed interested in the wood-working and computer-automated manufacturing projects that teacher Ron Cox was assigning in his technology courses. (p. 14). However, the girls would always shy away from taking his classes, regardless of how interested they seemed to be in the learning experience (p. 14). In an attempt to increase female enrollment in technology courses, Cox introduced an all-girls course: woodworking for girls. (p. 14) The course was a tremendous success; classes always reached maximum enrollment numbers, and students highly enjoyed the course. (p. 14)

**Effects of Stereotype Threat on Female Students**

According to Picho and Stephens (2012), stereotype threat (ST) has been conceptualized as “concern and anxiety over confirming a negative stereotype about an individual’s group.” (p. 53) In further explanation, this concept has to do with the perpetuation of negative stereotypes about girls’ abilities, or lack thereof, to participate, identify with, and perform well in non-traditional fields such as math and the sciences. Through their qualitative research study of female high-school students in Uganda, Picho and Stephens (2012) report that when a negative stereotype about an individual’s ability to perform in a certain field is perpetuated (such as a girl’s inability to perform well in mathematics), the individual feels threatened by the possibility of reifying the stereotype. Thus, as a result of ensuing anxiety about the stereotype, the individual significantly
under-performs in comparison to how they otherwise would have performed in the absence of the stereotype. (p. 53) Interestingly, although ST impacted girls’ performances in a co-educational school, it did not affect girls’ performances in an all-girls school. Picho and Stephens (2012) assert that the reason these findings differ may be due to the fact that students from the all-girls school reported higher levels of self-efficacy and identification in mathematics than students from the co-educational school. (p. 53)

According to the ST model, studies consistently show that when negative stereotypes about women in mathematics are perpetuated, female students tend to underperform in mathematics-related tasks. (Picho and Stephens, 2012, p. 53) Picho and Stephens (2012) refer to a study conducted by Spencer et al. (1997) in which findings show that female students under-performed in comparison to male students on a challenging Record Evaluation test after being exposed to statements asserting that gender differences (favouring male students) were typical among test results. (p. 53) A girls-only version of this experiment was conducted during the same study, whereby Spencer et al. (1997) placed the female participants in two distinct groups: an experimental group in which participants were primed with assertions of gender differences in test scores, and a control group in which there was no mention of any gender differences. (Picho and Stephens, 2012, p. 53) The results of this experiment were consistent with the findings from the initial experiment, as participants from the experimental group performed worse on the test than their counterparts in the control group. (p. 53) Furthermore, Picho and Stephens (2012) assert that studies show ST negatively impacts female students across various cultural and geographic groups, and that it begins to affect girls at a very young age (as early as five years old).
Differential treatment of girls

Picho and Stephens (2012) explain that in various countries throughout the world, negative stereotypes about girls’ mathematics abilities are reinforced through differential treatment of girls by the general society, at school, and in the home. (p. 53) This is manifested through the underrepresentation of women in science and mathematics-related professions like engineering, low teacher expectations of female students in the mathematics classroom, and low parental expectations of their daughters on mathematics-related tests and assignments. (p. 53)

In terms of gender role socialization, a study conducted by Gordon (1995) of teachers’ expectations of their students in Zimbabwe schools revealed that both male and female teachers are proponents of the belief that girls and boys possess gender-specific potential, aptitude, and intellectual ability, and that as teachers, they are responsible for guiding students toward those gender-specific roles and occupations. (Picho and Stephens, 2012, p. 53) In further detail, the study shows that these teachers perceive boys as being more intelligent, more serious about school, and more capable of grasping complex concepts than girls. (p. 53)

Gordon (1998) conducted a follow-up study of student attitudes three years after the initial research study. In the subsequent study, findings show that male high school students express similar stereotypes to those expressed by teachers in the previous study: 36% of male students believe that young women are not as intelligent as young men, and 50.6% believe in the notion that males and females are equally intelligent, but are intelligent in different ways. (Picho and Stephens, 2012, p. 54) Consistent with gender role stereotypes, participants from the study asserted that female students are most intelligent in the fields of fabrics, fashion, and food and nutrition, while male students are
most intelligent in the sciences and are better suited than females for careers in engineering, aviation, and mechanics. (p. 54)

Congruent with findings from the studies conducted by Gordon (1995, 1998), Hembrow-Beach (2011) asserts that even today, the girls still face differential gender treatment in the co-educational classroom. (p. 4) Hembrow-Beach (2011) explains, “While test scores may indicate that girls are improving in comparison to their male colleagues, girls receive less and different attention from teachers than their male peers do.” (p. 4) Interestingly, Hembrow-Beach (2011) goes on to assert that this is not the case in all-girls schools, where girls do not experience differential treatment based on gender. (p. 4)

Hembrow-Beach (2011) states that all-girls learning environments provide female students with more empowerment than co-educational learning environments, and that the differential treatment experienced by girls in co-educational school settings causes them to fall behind in academic performance as well as in developing a healthy sense of self-esteem. (p. 9) Furthermore, Hembrow-Beach (2011) reinforces what other researchers have already shown in stating that the problem of differential treatment based on gender appears to be most egregious in mathematics and the sciences. (p. 7) She references a study of British schools conducted by Younger et al. (1999) whereby findings reveal that teachers tend to provide boys with more educational encouragement and direct teaching than girls, because boys are often seen as disruptive and off-task whereas girls are perceived to be diligent in the classroom. (Hembrow-Beach, 2011, p. 13) As a result, girls receive differential treatment resulting in “less learning support and teacher attention than their male peers.” (p. 13)
Together, this cross-cultural collection of research studies shows that the differential treatment of girls by their male peers, parents, and teachers is shown to have detrimental effects on girls’ interest, participation, and achievement in non-traditional fields of study.
Chapter Three: Methodology

Procedure

This is a qualitative research study. Through it, I investigate the efficacy of all-girls learning environments by attempting to answer the following research question: “How are all girls schools effective in stimulating girls’ interest, participation, and self-confidence in non-traditional fields of study?” Aspects I investigate through this study include the representation of females in non-traditional fields of study, the effects of all-girls learning environments in comparison to co-educational learning environments on female students’ educational experiences, strategies for increasing female students’ involvement in non-traditional fields, as well as the effects of stereotype threat on female students in the classroom.

In my research study, I look at current Canadian and international research findings (presented in the literature review) and compare them to my own findings gathered from semi-structured, face-to-face interviews with four mathematics and science teachers from two different all-girls schools in the Greater Toronto Area. I provided all of my research participants with a list of the interview questions in preparation for their interviews. All participants also signed a consent form prior to commencing their interviews (Appendix A). After interviewing all participants, I transcribed the interviews and examined the research findings. I present a discussion of the findings in the concluding chapter of this research study.
Instruments of Data Collection

Instruments of data collection I used include semi-structured face-to-face interviews, a formal consent letter, a list of specified interview questions, and a tape recording device to ensure accuracy in record keeping and transcribing. I used the general interview guide approach, which is ideal because it is more structured than the informal conversational interview approach yet still allows for some flexibility (Turner, 2010, p. 755). During the interviews, I asked questions such as, “Please tell me about your students’ attitudes and interests when engaging in math and/or science. Generally, are the female students’ attitudes and interests positive or negative? How do you know?” and “What teaching strategies do you use, if any, to stimulate interest in math and/or science among female students?” The complete list of interview questions is appended at the end of this paper (Appendix B).

Participants

The participants I chose for this study are four science and mathematics teachers; two are male and two are female. All participants have at least ten years of teaching experience, and they have all had extensive experience teaching in all-girls environments. All participants have also taught in co-educational settings at some point in their careers.

Becky and Nerina are both teachers at the same all-girls school, which is a private K-12 school in the Greater Toronto Area consisting of approximately 120 students. Becky and Nerina are both currently still teaching at the same school. Emerson and Michael were both teachers at the same publicly funded all-girls Catholic high school in the Greater Toronto Area, consisting of approximately 850 students. Emerson still

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1 Pseudonyms were used for all participants.
teaches mathematics at the all-girls school, and Michael now teaches a science teachable course for bachelor of education students.

I compared the findings from all four interviews for similarities and differences, and in order to determine if any patterns exist. I chose to interview participants from two radically different all-girls schools because I wanted to ensure that the findings were directly attributed to the fact that each school is an all-girls school, and that findings were not attributed to any other similarity between the two learning environments. For example, if both schools are all-girls schools with small enrollment sizes, it could be difficult to determine whether or not patterns from the participants’ responses are attributed to the fact that both schools are all-girls schools, or simply because they are both small schools.

Hence, in order to avoid misinterpreting data, I chose to interview one math and one science teacher each from two radically different all-girls schools in the Greater Toronto Area. Becky and Nerina are participants from The Lorde Institute\(^2\), which has approximately 120 students from kindergarten to grade twelve and is a privately funded school with no religious affiliation. The second school I chose is St. Helen High School. Emerson and Michael are both participants from St. Helen High School, which has approximately 850 students from grades nine to twelve, and is a publicly funded Catholic school.

**Data Collection and Analysis**

In order to ensure accuracy when recording my data, I audio recorded each interview on my laptop using an Apple application called Garage Band. Using this

\(^2\) Pseudonyms were used for both schools.
application, I was then able to slow down the tempo of the audio recording in order to accurately transcribe each interview into a Microsoft Word document. In order to analyze the data, I began by reading and rereading the transcribed interviews, I made notes on my comparisons, and I recorded emergent themes. I then used different colours to code the findings based on themes. The findings are presented in Chapter Four, which will be followed by a discussion in Chapter Five.

**Ethical Review Procedures**

Certain agreed-upon standards for research have been set out by the Ontario Institute for Studies in Education of the University of Toronto in order to ensure that ethical research practices are maintained throughout the entire research process. The privacy, needs, and concerns of all participants are taken very seriously; hence, I made sure to adhere to all ethical review approval procedures throughout the course of my study.

The ethical review process began with the selection of participants. I approached participants through each school’s office administration first, in order to ensure that I had gained the school’s consent to approach potential participants. Once I selected the participants, I presented each interviewee with a formal participation consent letter (see Appendix A for a copy of the informed consent letter). Through the signing of this letter, participants indicate that I have explained the topic of the interview, and that I have answered any questions they may have had about the research. Prior to signing, I ensured that my participants are aware that they can withdraw their participation from the research piece without penalty at any time. Furthermore, participants understand that they
may revisit the transcribed interview responses and/or retain a copy of the transcription upon their request. I also informed all participants of how I plan to use their contributions in my study, and that I will acknowledge them for their participation and contributions to my research under a pseudonym in order to protect their anonymity.

Finally, I regarded the respect for all persons participating in this research study as essentially important throughout the entire research process. In addition to ensuring the use of pseudonyms to protect anonymity, I also made sure to handle raw data with the utmost care. I audio recorded all interviews and later transcribed the data onto my password-protected personal laptop computer in order to ensure that the data remains private.

**Limitations**

Before beginning the interview process, I identified one foreseeable limitation to my research study: time constraint. The Master of Teaching program for which this research study is being conducted has a duration of only two years. Due to the nature of the program, the processes of data collection, data analysis, and reporting of findings do not commence until the second year of the program. As a researcher, this gives me a very narrow window of time to carry out my study and report on my findings. As a result, my findings are based only on interviews, and may not be as in-depth as they could be if more time was allotted to the study. If this study was conducted as part of a longer program, or if more time was dedicated to the study as opposed to coursework, a careful long-term observation of participants’ classrooms would take place in addition to the interview process. Furthermore, the research participant pool would be larger. These conditions would a more complete picture of the efficacy of all-girls learning
environments on helping girls combat the chilly climate of the sciences and other non-traditional fields of study.

Upon concluding my study, I identified second and third limitations. The second limitation that emerged throughout the research process was difficulty finding and contacting participants. Due to the fact that there are few all-girls schools in the GTA, I found it very challenging to find participants that were eligible and willing to be interviewed. Furthermore, once I had chosen my participants, it took a much longer time than expected for the interviews to be scheduled due mostly because one of the schools had not returned my calls or emails after I initially sought permission to recruit their teachers as potential participants.

Finally, the third limitation is a methodological one. Due to the limited scope of the program and project, I was unable to investigate the specific cultural dynamics which impact gender, which are no doubt critical for understanding gender in school settings.
Chapter Four: Findings

In this chapter, I present the data gathered from the four interviews with math and science teachers (Becky, Emerson, Michael, and Nerina). I have categorized the data into the following seven themes: 1) Positive influence of STEM role models, 2) Positive effects of all-girls learning environments, 3) Negative effects of co-educational learning environments 4) Strategies that increase female interest, participation, and self-confidence in STEM, 5) Female students’ common beliefs, attitudes, and engagement when learning STEM, 6) School and classroom climate in all-girls learning environments, and 7) Negative effect of stereotype threat on girls’ self perceptions.

Positive Influence of STEM Role Models

During their interviews, all four research participants expressed the common belief that having a STEM role model has a significant positive impact on girls’ learning. Furthermore, three out of four participants also reflected on their own past experiences and mentioned that they too had STEM role models that positively influenced their desire to learn, and eventually teach, STEM subjects. During her interview, Becky speaks about having had several influential STEM role models. Reflecting on her past, Becky explains,

I would get home from school, and as soon as I got home from grad school, I would take like a half an hour break just to, because there’s so much reading and work in grad school, I would take a half an hour break to eat a snack and just to watch the TV, and what was always on was Bill Nye. And I just thought, that is so fun! And it just stuck in the back of my head. I just admired him. I admired what he did, and I thought, you know, when it came to teaching, that was really, other than my mother and grandmother who are also teachers, that was such a big role model for me, and I just thought, you know, his style – the accessibility and humor of it – really appealed to me. That was my main motivation.

Currently, Becky is demonstrating her belief in the positive influence of role models in
her school, The Lorde Institute, via her implementation of a computer programming mentorship club in which girls will learn about computer programming during the first year of implementation, and will go on to teach incoming students about computer programming in subsequent years.

Expressing a similar belief in the positive influence of role models, Emerson states,

I think the key for these girls is seeing someone who has been successful in mathematics come back and talk to them. The problem, of course is there are significantly more role models that come from business. You know, I haven’t been able to make connections with computer science scientists out there, or theoretical mathematicians, or math university professors, who are doing extremely well and who are female. That’s been really difficult to do.

In reference to Anderson and Gilbride’s (2007) research as presented in the literature review, one of the documented reasons for girls not choosing to pursue studies or careers in STEM includes the lack of strong female role models (p. 1). Over time, research has continuously shown that women are under-represented in the fields of math, science, information technology and engineering. Anderson and Gilbride (2007) explain that female university students in Canada represent less than 25% of students enrolled nationally in engineering programs, even though they make up more than 50% of the overall university population (p. 1).

Like Becky, Michael and Nerina also think back to their own past experiences with STEM role models. In response to my question of what motivated him to pursue a career as a science teacher, Michael very simply states, “In senior high school, I had a really cool chemistry teacher. And I said, ‘Okay. Yup. This is it!’” Expressing a similar sentiment, Nerina reflects on her experience while learning math in elementary school.
and explains that her main motivation for becoming a math teacher was her role model’s influence. In response to my question about what motivated her to become a math teacher, Nerina states,

My grade 8 math teacher. He actually was a great mathematician. He was one of those people that taught at the all-girls school in Iran. And I think the way he taught math was amazing. There was a lot of thinking going on, and we all fell in love with math. I fell in love with the way he was teaching.

Overall, all four participants agreed that having a STEM role model has a significant positive effect on girls by increasing their motivation to learn STEM subjects.

**Positive Effects of All-Girls Learning Environments**

My research shows that all-girls learning environments are most beneficial to girls’ academic achievements in STEM because girls feel more comfortable participating and expressing themselves, because they are more willing to take risks, and because there are fewer classroom management issues as opposed to in co-educational settings.

**Girls feel more comfortable participating and expressing themselves**

Becky speaks about girls’ increased comfort and freedom to express themselves when they are in an all-girls learning environment as opposed to a co-educational learning environment. She explains,

Girls, when left to be themselves without the influence of boys, probably feel freer to make more noise. And they do. And people are very different you know? Some girls are very quiet and studious and read a lot, and listen to instructions really quickly. Other girls are different. And I think that’s the nice thing about being with just girls. It’s that you get to see who they really are, without the pressure of performing in a way. They don’t need protection exactly, but it’s about comfort; like women’s only gyms.
In addition to freedom of expression in terms of participating being heard, Becky also goes on to talk about girls’ comfort when it comes to expressing their honest opinions. Becky states, “Just due to the environment here, I think they feel more comfortable expressing their honest opinions.”

On a similar note, Michael states girls feel more comfortable participating during science class because there are fewer social impediments to learning in all-girls schools as opposed to in co-educational schools. Michael states,

In the all-girls environment they just matter-of-factly do science and math. Especially when you’re doing lab activities. You know it’s just, “get in there and do it”. They just do. You take the guys out of the classroom, and the girls are a lot more engaged. And there’s none of the social impediments that are in place. Um, “Yeah it’s physics. I take physics. Why not?” It’s a non-issue.

This indicates that, in Michael’s experience, girls benefit from being in an all-girls learning environment when learning science because they are more likely to be engaged in scientific learning tasks.

**Girls feel more willing to take risks**

Emerson talks about all-girls schools as effective learning environments because girls feel more comfortable taking risks in STEM classes when boys are not present. He explains,

There is a difference in their learning environment that allows them to take risks and feel more comfortable admitting that they don’t know things. They don’t want to be the dumb girl in their class, you know, especially if there’s a guy that they have a crush on in the class or they like each other, whereas that’s not really there in an all-girls school. That’s what I’ve found. They’re more willing to admit that they don’t know something. It is a safer environment.
Emerson’s view is consistent with Michael’s view about the negative social effect of a co-educational environment on girls’ learning, which tends to manifest itself in the form of girls’ reluctance to participate or to be fully engaged in learning tasks.

**Fewer classroom management issues**

Reflecting on his experiences with classroom management issues while teaching in a co-educational school and comparing it to his experiences while teaching at an all-girls school, Emerson explains that there is a tremendous difference between the two school environments. Emerson states,

I would say, that even in the worst applied level classes that I’ve taught at the all-girls school, their behaviour is still better than in the co-ed school classroom... with the exception of lates or the odd time a student skips, I have zero classroom management problems. Which means that I can spend one hundred percent of my time on making sure the girls understand curriculum expectations, and if they have questions about them, and making sure that they’re able to learn in that environment.

Furthermore, Emerson reflects on the implications of this difference by explaining that he can be a more effective teacher at an all-girls school due to the absence of classroom management issues. He explains,

You notice that the classroom management problems aren’t there and it makes you more available to the students in the classroom, and happier as a teacher, that you can just teach kids the curriculum versus providing babysitting services and making sure they don’t misbehave.

Overall, the data from my research shows that girls are generally more likely to benefit from learning STEM subjects in all-girls versus co-educational learning environments because they feel more comfortable participating and expressing themselves, because they are more willing to take risks, and because there are fewer
classroom management issues that consume instructional time and distract students from learning.

**Negative Effects of Co-Educational Learning Environments**

All four participants speak a lot about the negative impacts of co-educational learning environments on girls’ learning. The most significant impacts identified in my data are that female students feel intimidated by male students’ presence in the classroom, that male students tend to dominate the classroom, and that girls learn differently than boys and would benefit from a bridged-gap approach to learning in the co-educational STEM classroom. My research findings are consistent with the findings from research studies cited in my literature review, which will be further explored below.

**Female students feel intimidated by male students’ presence**

Becky talks about the differences in female students’ behaviours when in the presence of male students. In co-educational learning environments, girls are more likely to feel intimidated by the male students’ presence, and consequently are less likely to be vocal or to participate during class. She explains,

> I mean I think in a mixed-gender class, the girls are quieter than the boys. I don’t think that’s because they’re naturally quieter. I think it’s just that the boys take up a lot of space.

Becky goes on to explain that she would make conscious efforts to call on girls during class lessons in order to increase their participation. However, as Becky states, “the problem was they didn’t raise their hands as much!”

Echoing Becky’s sentiments, Emerson also talks about girls’ quietness in the co-
educational classroom and attributes it to the presence of males. Emerson explains,

I think in some cases the boys’ very presence is a limitation. That’s not to be mean or cruel or anything. It’s a fact that in a lot of cases, girls are really, some girls, not all girls, they’re really focused on what the boys perceive of them and what the boys think of them, and they’re afraid to show that they don’t understand something. They’re afraid to show that they’re having difficulties with something because they’re worried about how that will impact the way they’re perceived by not only their female peers but by the males as well. They don’t want to be the dumb girl in their class, you know, especially if there’s a guy that they have a crush on in the class or they like each other. So a lot of the times girls remain quiet and didn’t say much. And they suffer in silence if they don’t understand stuff. They’re afraid to step forward, afraid to say something, because they’re afraid of their peers and such.

Like Becky and Emerson, Michael speaks about the negative impact of the male presence on female participation in the STEM classroom. In co-educational environments, female students are less likely to participate and are more likely to take on passive roles, while male students tend to dominate the classroom. He explains,

It’s a little bit more difficult to sometimes get girls to take on leadership roles when they’re doing lab activities. I hate to stereotype, but often the girls in the group are going to sit down and analyze it. And think about it. “Okay, what are we going to do here?” As opposed to guys that dive in and then realize what they’ve got... So the girls tend to take on more of a passive role.

Similarly to the other participants’ views, Nerina explains that she too notices that girls tend to be quieter when in the presence of boys when she states, “In a co-ed class, you hardly ever hear the girls.”

**Male students tend to dominate the classroom**

My research shows that male students tend to dominate the classroom, which causes girls to become passive learners. Becky talks about dominant roles and superiority complexes among male students, and about the negative effects of outnumbering. She wonders and explains,
Why are the girls in the science lab the recorders, and not the ones running the experiment? Why are they taking that on so much? I saw that again and again. Decision-making roles were left to the boys... They take up extra room because they’ve been given messages that they are superior and so I think that’s part of the problem... The sound of their voices was deafening in the room. And they were outnumbered. The girls were outnumbered by about 4 to 1 in that room, and it felt as if they had no space at all.

Becky continues on to talk about the underrepresentation of women and the negative impact of male dominance in computer science. She states,

Kids learn computer programming in clubs outside of school, but those clubs – I’ve had students here check them out and come back and go, “well there were only boys, so I don’t want to go.” Yet women by far are the biggest consumers of computer technology now. When it comes to purchasing and using computer technology, women do it more than men... However, the creators are still mostly men. So the people programming, the people developing, marketing, just in terms of production, are mostly men. So it would be nice to see more women’s voices there.

Furthermore, Becky shares her own experience with male dominance and female underrepresentation in computer science when she was a student. She recounts,

Before I decided to go to teacher’s college, I actually considered computer programming. I enrolled, got accepted, went to pay my tuition, and I was standing in line and I looked around at all the people there and went yeah, no. I, this is, I just, I just don’t feel, this feels wrong. It feels wrong. I didn’t analyze it a lot, but it just didn’t seem right. And I think, had I seen other women there my age, I think it would have been a different story.

As I have shown in my literature review, the data gathered from my interview with Becky supports the findings shown by Anderson and Gilbride (2007) who explain that two of the main documented reasons for girls not choosing engineering (including computer engineering) as a career includes the masculine image of engineering and the stress and isolation of being a minority (p. 1). Furthermore, in regards to female interest and participation in the field of information technology, Peckham (2009) states that increasing female enrollment numbers is a perpetual challenge for many technology
educators, and that girls usually shy away from taking technology courses even when they seem to be interested in learning technology-based skills. (p. 14).

**Girls and boys learn differently**

My research findings suggest that girls learn differently from boys and would benefit from a bridged-gap approach to learning in the STEM classroom. While talking about the different ways that female and male students approach scientific experiments in a lab, Michael states,

> Often the girls in the group are going to sit down and analyze it. And think about it. “Okay, what are we going to do here?” As opposed to guys that dive in and then realize what they’ve got. So the girls then are watching this, and because things are already progress, they tend to take on more of a passive role.

Here, Michael explains that female students and male students tend to approach learning tasks differently. By failing to differentiate instruction for female and male students, the result is that females tend to fall into passive roles while males take on active roles, thus creating a learning gap among the female and male students.

Nerina’s view also supports the idea that females and males learn differently, and she suggests that teachers should strive to find a way to connect the different ways of learning. She explains,

> In a co-ed school, one of the main problems is that you need to be able to connect the two ways that these two different groups of people learn. Boys learn by the teacher giving them formulas and explaining it to them, and then giving them examples. Girls need to be part of their own learning.

Overall, my research findings show that co-educational learning environments have negative impacts on female students in the STEM classroom as female students tend
to feel intimidated by male students’ presence in the classroom, male students tend to
dominate the classroom, and female students appear to learn differently than their male
counterparts.

**Strategies That Increase Female Self-Confidence, Participation, and Interest in STEM**

**Vary students’ roles**

Becky talks about the importance of varying students’ roles when working in
groups. She explains,

In a science setting, it’s not okay to always be the recorder. It’s also not ok to
always be the one running the experiment, or making the decisions about how the
experiment is set up. So I vary the roles that students are asked to take so they
don’t always, by default, fall into a supportive role as opposed to an active role
and vice versa.

Hence, varying students’ roles during group work is a strategy that can be used to help
prevent girls from habitually falling into passive roles.

**Make learning meaningful**

Becky explains that female students greatly benefit from learning math and
science in a way that is concrete and applicable to their lives outside the classroom. She
states,

Girls, especially at the junior age, really need to see how helpful for people like
them math and science can be. And I don’t just mean personally, but how they
can make the world a better place through math and science. Like, how can they
help animals they care about? Or how can they help people they care about? Or
how can they help the environment? It’s just, that personal connection is really
important. So I try to make things concrete, because if it’s too abstract, it’s not as
compelling. And I think that that’s probably a conscious way that I am going to
try and get girls excited about it. It’s to say, “Oh, hey look, these people are using
it to do this.” Or, “We could use it to do that.” Um, and also just making it fun.
You know, there should be cool stuff to look at and neat stuff to touch, and surprises along the way. And all of that’s important.

Becky provides an example of an authentic math task by talking about the school-wide social justice data fair that she arranged at The Lorde Institute. This project provided girls from all grades with the opportunity to select, hypothesize, and investigate a contemporary social justice issue from a mathematical point of view. For example, the students in the grade one and two combined class chose to investigate girls’ lack of education in some developing countries due to their roles as water carriers. The students decided to fundraise for UNICEF by making posters and placing donation jars at different places around the school, such as in the library, at the front desk, and in the gymnasium. Their mission was to check the jars every day and record the funds collected on a data sheet. The students hypothesized about which jar would collect the most money in order to determine the relationship between the location of the jar and the money collected.

Finally, the class pooled the funds and calculated a sum of the totals. They then made a check out to UNICEF donating all the funds collected, and took a class trip to UNICEF’s office to present them with the donation. While they were there, the girls had the opportunity to experience for themselves what it feels like to have to carry heavy water jugs by filling UNICEF jugs and trying to carry them like many of the girls do in developing countries. They then returned to The Lorde Institute and reported their findings at the social justice data fair. While talking about the grade one/two class’ presentation at the fair, Becky explains,

It’s an authentic math task. This is not different than what is done at UNICEF itself. Someone also does that. And that’s, that’s the exciting thing – when it’s not this fake made-up math. There are real world connections, and in a genuine way! I mean we genuinely needed this money counted! That’s the nice thing. And it’s
hard to pull that off. You can’t do that for every single expectation in the curriculum. You can’t be like, “Well I will find a genuinely authentic, useful reason to do this math today.” But you can take opportunities when possible.

Similarly to Becky, Emerson explains that he has made learning math meaningful for girls in his classes by relating the learning to issues of social justice. And, like Becky, he also raises a limitation to this strategy. Emerson explains,

I’ve done some work where the mathematics is very close to some issues of social justice. So the girls like that sort of discussion as well, because they have a keen interest in the world around them, from a socially just point of view. So that’s been one way that we’ve got them to do some of the math. But in some cases, taking a look at the problem and spending a day or two days looking at that problem when it’s only one of five types of questions for that particular curriculum expectation, and you haven’t even covered the entire expectation, and you’ve got eighty other expectations to work through, it takes too long. It’s great to be able to do that, but it’s not something one can do on a regular consistent basis.

Although the provision of authentic and engaging math tasks makes learning meaningful for girls, Emerson raises a good point in stating that this can be very time consuming, and consequently is not something that can be done for each curriculum expectation. Becky agrees with Emerson’s view as she too states that it is unrealistic to expect to make every single learning task authentic and meaningful; however, teachers can certainly take opportunities to do this whenever possible.

**Establish a strong rapport**

Becky establishes a strong rapport with her students by being highly supportive, especially of struggling students, and by modeling a positive attitude toward STEM subjects. She emphasizes improvement over achievement, and she sets high expectations that students try their best. Becky states,
The work of Carol Dweck talks about Mindset - the idea of a growth mind set, which is adopting the attitude that with practice you’ll get better, and that just because you don’t know something now doesn’t mean you can’t know it in the future. And even the notion that your intelligence is not fixed, but plastic; that you can alter your own brain. So using this idea very explicitly in math and saying to kids that are like, “I can’t do this”, I say to them “you can’t do it yet”. And not letting kids opt out of math. Like, you don’t have to love it. I expect you to try, I will support you while you try. But failure is not an option. I combat that feeling of fear by just being super supportive and encouraging and positive, and saying I know that this is scary, I know you can do it, I’m here for extra help even a million times, and you know, it’s something you’re in together, and the kids have to know that.

Similarly to Becky, Emerson focuses on establishing a strong rapport with his students in order to make them feel comfortable learning math. Emerson explains,

Really the rapport I have with my students is really important to me. I think making them comfortable, first of all with me as a teacher, and second with the subject material, and in that order, would make them more likely to try new things. To try whatever the new material is that we’re learning without being overly anxious about things. It’s little intangible things where, if they feel comfortable with the teacher that they have, they are more willing to let their guard down and admit that they’re having difficulties and that they’re not understanding what it is that you’re talking about.

All four participants expressed, at some point during each of their interviews, that establishing a strong rapport with their students is of fundamental importance to girls’ success in the STEM classroom.

**Smaller class sizes**

Emerson shares his experience with having a small class at St. Helen High School, where class sizes are normally standard large classes. He explains,

One of the things we did last year is we had Dr. Leonard Sax, I believe his name is, who specializes in single gender education, he came up and talked to us as a staff and he gave us some interesting teaching strategies that really worked toward the way that girls learned. I happened to have really lucked out that semester because I had a really small class and I was able to implement some of his ideas right away. And I’ll give you a perfect example. The typical classroom setting of
students sitting in rows, um, he says well that’s probably not the best for girls because socially, if you watch how they gather, they tend to sit in circles, whereas boys tend to socialize in lines. You know, they’ll line up against the wall and watch things happen around them, whereas girls will naturally sit in a circle and discuss things. So that was one of the things I did because I had a very small class, there were only about 9 students, 10 with me. So I arranged 10 desks in a circle. The kids didn’t have assigned seats, everyone rotated. I didn’t have an assigned spot. At it worked very well... I would say that I probably have a really good relationship with that group of kids, and they feel really confident and comfortable, not only in math, but confident in growing up as adolescents. And I don’t think they would have had that opportunity if it was a typical classroom setting, with 28 desks in a row.

Similarly to Emerson’s experience, Becky and Nerina both have small class sizes at The Lorde Institute, and the girls in their classes also have circular or U-shaped seating arrangements.

**Create a comfortable learning environment**

Emerson states the importance of creating a safe learning space, and he explains that he does not tolerate any kind of teasing in his math classes when it comes to students’ struggles or abilities to learn. He also explains that, as a teacher, it is important to show your students that you have faith in their learning abilities. Emerson explains,

> It all comes back to creating an environment where they’re comfortable and feel safe. And not a physical safety, but an emotional safety, where they’re safe to admit that they don’t understand anything. And I always set the rapport very early on that I won’t tolerate them teasing or making fun of each other for not understanding a math concept. I always jokingly tell them, “If you put up your hand and say you haven’t got a clue what I was just talking about, no one is going to laugh. But if you come in with green hair tomorrow, we’re all going to laugh. Because, who comes in with green hair ?!” So I always, always had a rapport where I really would not tolerate them putting themselves down, or each other down, for not being able to do the math and engage in the math. In a lot of cases they’re their worst cheerleaders. They put themselves down because they’re just used to having the attitude that they’re awful at it.
Hence, teachers need to focus on establishing a good rapport with their students in order to help boost girls’ self-confidence in their STEM abilities.

**Engage students with stuff**

Michael talks about his experiences teaching Bachelor of Education students who have science as their teachable subject. He explains,

My big mantra at faculty is, um, I tell them all, “We teach science with stuff”. It may sound a little stupid but I tell my students, the teacher candidates, “You’re going into a science classroom; I want you to feel naked if you don’t have something with you!” Whether it’s a, you know, a cart full of chemicals, a box of models, or a dissected frog, or whatever. But bring in something. Show them stuff, and engage them with your stuff. It could be a video even. So then they ask, “Hey Sir, what’s that?” and “How does it work?” And off goes the lesson.

Michael’s advice to his teacher candidates indicates that it is important to engage students from the very start of the lesson by showing them something that will spark their curiosity and invite them to participate in the learning experience.

**Promote discussion**

Nerina explains the importance of promoting discussion among the students in her senior math classes. She states,

The relation between math and everyday life is very important for girls. Girls need to participate and discuss and argue. And that is what happens here. I let them have the discussion. I don’t answer questions very often. I let them answer them. One thing that I found very important is not using work sheets in a classroom. Have a discussion. Everyone is included. When you give them work to do on their own, it’s busy work. Although girls, I mean, all students, need repetition, they need to work on some stuff. But a lot of memorization happens when you give out work sheets. My strategy is to make them understand, and then work on a rather difficult question that includes thinking, knowledge and understanding, application, and communication. Just one or two questions. When you give them one of these in the classroom, they start discussing it. Those who
don’t understand listen for the second, third, fourth time because someone is explaining it to someone else. Everything is happening aloud. So the repetition happens while you are talking rather than writing. One of our co-founders, I always say very proudly, said, “Nerina’s math classes are like political debates. It doesn’t sound like a math class.” And it’s because they argue with each other. They talk about this.

Hence, through promoting group discussions in her math classroom, Nerina is able to maximize students’ understanding and participation.

**Female Students’ Common Beliefs, Attitudes, and Engagement When Learning STEM**

When asked to describe their female students’ commonly held beliefs, attitudes, and engagement when learning STEM subjects, the research participants had varying answers. During my interview with Nerina, she explained that in her experience, students’ attitudes are more likely to be negative and resistance is more likely to occur when they are coming to the all-girls school from a co-educational school. Nerina states,

**Those who come from other schools to The Lorde Institute, about 75% of the time, have a negative attitude towards math. Unless they have been doing very well.**

Becky, who also teaches at The Lorde Institute, shares a similar view to that of Nerina’s. Becky states that in her science class, the girls’ attitudes are generally positive except for new students who came to The Lorde Institute from another school. When asked to comment on her students’ attitudes during science, Becky responds,

**During science, positive. Like, almost 100% positive. In fact, the only time students come with a negative attitude towards science is because when they were in their previous school, science had been: “read this page, answer these 4 questions”. And that was science. And, and so, once, you know, we start doing actual science, which involves stuff, no resistance. Math is a different story. It’s harder. It just is. I do make it my personal mission to increase attitudes towards positive.**
Although Becky shares a similar view to that of Nerina’s when speaking about girls’
attitudes in her science class, her answer is more similar to that of Emerson’s when it
comes to her students’ attitudes during math. Emerson, who answered the question very
differently from Nerina, states,

The girls, they love going to their English classes. They like going to their biology
classes, they tolerate physics, they dislike math. Sometimes, I say to people when
they ask me what do I do for a living, I say I am a teacher, and they say, “Well,
what do you teach?” Well my first reaction is, “I teach kids.” And then they ask,
“Well, what do you teach them?” I tell them, “I’m selling a product that no one
wants to buy.” It’s pretty accurate. Because I would say that in your typical
classroom of twenty-five students, maybe I have two students who are there
because they enjoy the math. The rest of them are there because they have to be
there. They have to take the course to move on to whatever their career path is.
It’s a prerequisite to something else, or whatever.

Similarly to Becky, Emerson’s students’ attitudes and beliefs about learning math tend to
be negative in general.

**Resistance to learning**

When asked to talk about any resistance to learning in the STEM classroom,
participants described various ways that resistance takes shape. Michael explains that his
female science students demonstrate more of an obvious resistance through their
“resistance to taking a risk” during experiments and group work, whereas in Emerson’s
math classes, the girls tend to show subtler resistance by choosing not to do their
homework. Emerson explains,

Well, the resistance is not in your face resistance. It’s more subtle. They won’t do
the homework and it’s usually because they don’t get it. They definitely do come
in on the first day with a negative attitude. Not all of them, some of them are quite
good at math and they enjoy math, but that’s not the majority. The majority has a
significant amount of anxiety, and the anxiety manifests itself by not wanting to
do the work. They are more likely to, if they have the choice between working on
two different courses at home, spend more time working on something that interests them. Then it’s not as anxious for them to work on it, because they have more success in it.

Contrastingly, in Nerina’s experience, there is little resistance in her math classes. Nerina talks about resistance being prevalent among girls who came from co-educational schools rather as opposed to girls who have been at The Lorde Institute from the beginning. She states,

The resistance is usually by the ones who come from another school. Not from our kids – the kids who have been at The Lorde Institute.

Perhaps the reason for the difference in the participants’ answers is that most of the students at The Lorde Institute have been at the all-girls school since the first grade, whereas Emerson’s students have only been attending St. Helen High School since the ninth grade, and almost all of those students have come to the all-girls high school from co-educational elementary schools.

**School and Classroom Climate in All-Girls Learning Environments**

All four research participants indicated throughout their interviews that all-girls schools offer a more welcoming environment for girls as opposed to co-educational school, especially when it comes to STEM classes. For instance, Nerina explained that her students generally “feel comfortable enough to ask questions,” whereas girls in co-educational learning environments tend to remain quiet during class discussions.

During my interview with Becky, she explained that it is easier to empower the female learner in an all-girls learning environment because feminist pedagogy can be taught without receiving backlash. Becky explains,
Sometimes people hear a pro-girl message as an anti-boy message, and that’s not true necessarily. It’s not true at all. I want boys to do well in school, I want boys to be excited about things, I want boys to have happy lives. It’s just that if somebody has less power, I want them to have equal power, and sometimes people interpret that as taking away from boys.

Furthermore, when asked to comment about her thoughts on the difference between all-girl and co-educational learning environments, based on her personal experiences, Becky explained that the mere presence of male students changes the school’s climate for girls. She states,

It’s funny. Like, even just with interaction in the hall, the presence of boys adds a different energy that comes into the classroom. Even if it’s a girls-only learning space.

Similarly, Emerson agrees that the climate at an all-girls school is very different than at a co-educational school when it comes to girls learning STEM. Emerson states,

It is a different environment. There are a lot of intangibles, and you can’t just point a finger at one or two. It’s the culmination of 10 or 15 intangibles that makes the environment completely different. And it is significantly different.

Interestingly, Michael explains that when it comes to taking STEM courses, at St. Helen High School, the all-girl school he taught science at, the enrollment was very high. Michael states,

In our setting, the enrollment in science is so strong, that if anything I wanted them to go elsewhere! You know, get into a sport, go play flag football!

Again, this reinforces the notion that all-girls schools are effective in increasing girls’ interest and participation in STEM subjects.
Negative Effect of Stereotype Threat on Girls’ Self Perceptions

As shown in the literature review, Picho and Stephens (2012) explain that in various countries throughout the world, negative stereotypes about girls’ mathematics abilities are reinforced through differential treatment of girls by the general society, at school, and in the home (p. 53). This is manifested through the underrepresentation of women in science and mathematics-related professions like engineering, low teacher expectations of female students in the mathematics classroom, and low parental expectations of their daughters on mathematics-related tests and assignments. This is consistent with the following findings from my research study.

What stereotype threat looks like in the STEM classroom

Findings from my research study suggest that stereotype threat is still a barrier that girls face in STEM classrooms today. When asked to describe what stereotype threat looks like in her science classroom, Becky explains,

There was a Barbie that came out a few years ago. That, like, one of her, like you could pull a string and she would say something. And then one of the things was, “Math is hard.” And, you know, like, that sort of stereotype, just to call it out and say like, “Hey, isn’t that dumb?”

Becky goes on to give another example of what stereotype threat looks like by talking about the stereotypes present in a math textbook she came across. She explains,

There was also a book that came out recently that was well meaning. It was about getting girls interested in math. But the examples were all about shopping and clothes. It was trying to dispel one stereotype by reinforcing another one.

Becky’s responses show that it is important for teachers to talk about the wrongfulness of stereotypes presented in learning materials instead of simply ignoring them.
Causes and effects of stereotype threat on the female STEM learner

Emerson reflects on his experiences teaching girls senior math. He talks about the girls’ self perceptions and states,

They tend to come with a lot of baggage in terms of their preconceived ideas that they can’t do math. So where that starts from has sort of been an unknown. Well, not really. It would have been elementary school, that’s where I’m thinking it would have come from.

Like Emerson, Nerina also speaks about her experience with girls’ negative self-perceptions when it comes to their own abilities in math as a result of stereotype threat, as she shares an experience she had while talking to a new student in her math class at The Lorde Institute. Nerina recounts,

In a co-ed class, you hardly ever hear the girls. I had a student who came from a co-ed school. And she was a very, very bright young woman. And when she sat in my grade eleven class, I realized that she understands the math and she’s able to do it, but she was hesitant to participate. So I took her aside and I said, “Was it cool not to be good in your other school?” And she said, “Yes. The boys don’t like girls who think.” That is the belief, unfortunately, of the girls, which is untrue... They pull back and they don’t want to show their intelligence. So in a co-ed school there is a lot of resistance. Because, as I told you, there is a myth that the girls are not supposed to be good at these things. And then, especially, if you want to have a boyfriend amongst your classmates or in your school. And the funny part is, I’ve taught in Iran, I’ve taught in England and I’ve taught here. It’s the same everywhere.

Nerina also explains that part of the problem is that some teachers treat girls differently than boys in the classroom. She explains,

I think the problem is the attitude of some teachers, actually, towards girls’ learning. And we hear this a lot that in a math or science class in a co-ed school: hardly ever do teachers ask girls to answer questions. Because boys have louder voices and yell the answers. I think that has always been the problem.

Becky expresses similar sentiments to Nerina’s. Becky states, “The default is that teachers call on boys more often when not consciously thinking not to do it.”
Interestingly, Emerson remarks that stereotype threat is still prevalent in the home as well. He speaks more about his experiences with stereotype threat and states,

I found this as well when I taught co-ed, and I’ll give you the perfect example. I’ve got a group of students in my grade twelve calculus class who’ve got no business taking calculus because their grade 11 marks were less than stellar. In some cases they barely passed grade 11. But yet they’re clinging on to math because there’s pressure being put on them by their parents. When I talked to their parents though, I found that in some cases, they were a little less resistant when you gave them the bad news that, “You know what, maybe math isn’t for your son. Maybe he needs to pick up a trade of some sort. Like an electrician or plumber, or something related that’s more hands-on because they don’t have an aptitude for math, or for science, or English, or maybe school isn’t their thing.” Whereas breaking that news to young ladies’ parents is a little bit more difficult because there are still these stereotypes in terms of what jobs are out there for them.

When asked to comment about the prevalence and effects of stereotype threat today, Emerson explains,

Things haven’t changed. I would say right now the engineering ratio of boys to girls is very similar to what it was when I was in university. You know when I did my first year in computer science there were 3 girls in my class. And that was it. And I would say, I don’t think it’s anywhere near even 25% now. I’m just guessing. I doubt it would be that high. And in your typical engineering programs, it was just about the same because I had friends in engineering, and there were the odd girls in their classes.

Through his response, Emerson expresses that stereotype threat is still alive and thriving in the academic world.

**Strategies for reducing prevalence and effects of stereotype threat**

When asked to share some ideas for reducing the prevalence and effects of stereotype threat in her science classroom, Becky provided a variety of strategies. For example, Becky suggests discussing examples of wrongful stereotypes with class, as well
as talking about why and how stereotype threat is harmful and inaccurate. She explains,

I guess calling it out in a gentle way when someone is disparaging toward math and science, ‘cause those messages are really common. Especially when it comes to girls. Bringing in examples of how girls’ achievements in math and science have been belittled. I do that. You have to be actively battling the stereotype. So you need to say explicitly that the stereotype is that girls are not as good in math. The reality is here’s this study, here’s this study, here’s my experience. This is just not true. And you need to remind people of that, because the stereotypes are very pervasive and sneaky.

Another strategy Becky suggests is for teachers to keep a tally of the number of girls and boys they call on during class discussions in order to call on both genders more equally. She explains,

I keep a little tally, a list of girls and boys, and I make a tick every time I call on a student. It’s to keep track of their gender, as a way of making sure I’m not more often calling on boys, because the default is people call on boys more often when not consciously thinking not to do it.

Through the use of strategies such as this one, teachers at co-educational schools can be more mindful of making sure girls and boys have equal opportunities to participate.
Chapter Five: Discussion

Implications and Recommendations

Although all-girls schools are proven to be more effective in increasing female students’ interest, participation, and self-confidence in STEM, I recognize that the majority of Ontario schools are co-educational schools. Hence, what I intend to do with my research is to bring the strategies that effective teachers at all-girls schools are using into the co-educational classroom setting in order to help more girls succeed in STEM. Below is a list of recommended strategies gathered from my research:

School-implemented strategies

- Offer smaller class sizes

- Offer girls-only courses or clubs that promote girls’ interest and participation in STEM subjects, such as a girls-only math class or a girls-only computer programming club

Teacher-implemented strategies

- Have students sit in a class circle rather than in rows

- Vary students’ roles during labs or other group work so that girls and boys both receive equal opportunities to take on active leadership roles

- Make learning meaningful by helping students identify real-world applications

- Establish a strong rapport with the class from the very beginning in order to create a comfortable learning environment where students feel safe and valued

- Engage students with “stuff” such as by conducting experiments, instead of
relying heavily on handouts or textbooks

- Encourage participation and engagement by facilitating class discussions as opposed to silent independent work
- Practice mindfulness of gender equality when calling on students to participate during class discussions (by selecting boys and girls equally)
- Encourage girls to take risks and remind them that it’s okay to make mistakes

Through completing this research study I have learned how to be more aware of gender inequalities in my future classes, especially while teaching STEM subjects. Now that I know more about the negative effects of stereotype threat and have researched strategies teachers use for combating these effects, I feel better equipped to help girls succeed when I teach them math and science.

**Connections to Literature Review**

As I have shown throughout Chapter Four, the participants echo many of the themes presented in the literature. All four participants demonstrate awareness and understanding of the effects of stereotype threat on female students learning STEM subjects, and they all provide unique strategies that help increase female students’ interest, participation, and self-confidence in these subjects. Furthermore, the three main areas in which participants’ responses connect with the information I present in the literature review are: 1) Positive influence of STEM role models, 2) Under-representation of women in STEM, and 3) Stereotype threat in the STEM classroom.
Positive influence of STEM role models

Becky, Michael, and Nerina speak about the positive impacts that their own role models had on them while they were growing up and they list their role models as people who influenced them to pursue careers in teaching STEM. Becky and Emerson also speak more in-depth about how important and beneficial it is for girls to have strong STEM role models to look up to because it motivates them to pursue studies in STEM. This echoes Anderson and Gilbride’s (2007) research, in which they state that one of the documented reasons for girls not choosing to pursue studies or careers in STEM includes the lack of strong female role models. (p. 1) Emerson really speaks to this when he talks about how important he believes role models are for girls, and about how difficult it has been for him to get in contact with women who have been successful in pursuing careers in math or computer science due to the fact that most women he knows who have pursued careers in non-traditional fields of study ended up having careers in business.

Under-representation of women in STEM

Interestingly, in response to a question about the prevalence of stereotype threat in schools today, Emerson once again echoes the findings from Anderson and Gilbride’s (2007) study in which they explain that female university students in Canada represent less than 25% of students enrolled nationally in engineering programs, even though they make up more than 50% of the overall university population. (p. 1) Emerson mirrors these findings when he explains his view that things haven’t changed in terms of female enrollment in university STEM course, as the current engineering ratio of boys to girls is very similar to what it was when he was in university.
In reflecting on her own personal experience with backing out of her university acceptance to a computer engineering program, Becky also echoes the findings from Anderson and Gilbride’s (2007) study, specifically the part where they explain that two of the main documented reasons for girls not choosing engineering (including computer engineering) as a career includes the masculine image of engineering and the stress and isolation of being a minority. (p. 1) Becky relates to these findings in stating that when she went to pay her tuition fees at the university, she realized that she was severely outnumbered by men and this made her decide to withdraw from the program.

In recounting this experience, Becky also echoes the findings from Peckham’s (2009) study, which shows that girls usually shy away from taking technology courses even when they seem to be interested in learning technology-based skills. (p. 14) In Becky’s case, she shied away from pursuing studies in the field she was interested in because she felt uncomfortable knowing that the vast majority of those enrolled in the course were men. Becky also talks about this idea of girls shying away from studying technology through her experience with the girls in her classes who were interested in extra-curricular computer programming opportunities, but who returned to school feeling discouraged and intimidated by the over-representation of boys (and consequent under-representation of girls) that existed.

**Stereotype threat in the STEM classroom**

According to the stereotype threat model, studies consistently show that when negative stereotypes about women in mathematics are perpetuated, female students tend to underperform in mathematics-related tasks. (Picho and Stephens, 2012, p. 53) This piece of research is most clearly echoed by Nerina, Emerson, and Michael, who each
speak about the ways stereotype threat is manifested in their classrooms. Nerina shares her experiences about welcoming girls to her math classes who are new to the Lorde Institute, and speaks in detail about how one particular student had come to the school with the attitude and belief that, “... boys don’t like girls who think.”

Furthermore, Emerson and Michael both speak about their experiences having girls in their classes who purposely remain quiet and refrain from participating during math and science classes because of the stereotypes and social expectations that their male peers hold about them. For example, Michael speaks about a student who held herself back from participating during night school science classes because she didn’t want to make her boyfriend feel bad for being smarter than him.

**Limitations**

As I mentioned in Chapter three, I identified one potential limitation prior to the commencement of the research study: time constraint. As I carried out the research study, the following second and third limitations arose: difficulty finding and contacting participants, and inability to investigate cultural dynamics.

**Time constraint**

The first limitation I encountered was time constraint. As a researcher, I had a very narrow window of time to carry out my study and report on my findings due to the busy nature of the Master of Teaching (MT) program. The MT program includes a full course load with mandatory in-class attendance, as well as four full-time, month-long practice teaching blocks. This left me with a narrow time frame in which to contact and interview research participants.
Difficulty finding and contacting participants

A second limitation that emerged throughout the research process was difficulty finding and contacting participants. Due to the fact that there are few all-girls schools in the GTA, I found it very challenging to find participants that were eligible and willing to be interviewed. Furthermore, once I had chosen my participants, it took a much longer time than expected for all the interviews to be scheduled and completed. This was mostly due to the fact that one of the schools I contacted never returned my calls or emails after I initially sought permission from the school’s administration to recruit their teachers as potential participants.

Inability to investigate cultural dynamics

Due to the limited scope of the program and project, I was unable to investigate the specific cultural dynamics which impact gender, which are no doubt critical for understanding gender in school settings.

Further Study

The findings of this research study are qualitative in nature and are based on one-time interviews with four participants. Since the participants I interviewed are teachers, I suggest further studies should be carried out studying the experiences of female students from co-educational and from all-girls schools. Furthermore, I suggest that the studies should include female students of all grades from kindergarten to college/university, and incorporate a significant longitudinal component in order to determine any trends in female students’ self perceptions, interests, participation, and confidence levels with regards to studying STEM subjects over time. Further studies on this topic would paint a
more complete picture of the efficacy of all-girls learning environments on helping girls combat the chilly climate of the sciences and other non-traditional fields of study.
References


Appendices

Appendix A: Letter of Consent for Interview

Date: ___________________

Dear ___________________,

I am a graduate student at OISE, University of Toronto, and am currently enrolled as a Master of Teaching candidate. I am studying the efficacy of all-girls schools on increasing female students’ participation in STEM subjects for the purposes of investigating an educational topic as a major assignment for our program. I think that your knowledge and experience will provide insights into this topic.

I am writing a report on this study as a requirement of the Master of Teaching Program. My course instructor who is providing support for the process this year is Dr. Arlo Kempf. He is also my research supervisor. The purpose of this requirement is to allow us to become familiar with a variety of ways to do research. My data collection consists of a 40-minute interview that will be tape-recorded. I would be grateful if you would allow me to interview you at a place and time that is convenient to you. I can conduct the interview at your office or workplace, in a public place, or anywhere else that you might prefer.

The contents of this interview will be used for my assignment, which will include a final paper, as well as informal presentations to my classmates and/or potentially at a conference or publication. I will not use your name or anything else that might identify you in my written work, oral presentations, or publications. This information remains confidential. The only people who will have access to my assignment work will be my research supervisor and my course instructor. You are free to change your mind at any time, and to withdraw even after you have consented to participate. You may decline to answer any specific questions. I will destroy the tape recording after the paper has been presented and/or published which may take up to five years after the data has been collected. There are no known risks or benefits to you for assisting in the project, and I will share with you a copy of my notes to ensure accuracy.

Please sign the attached form, if you agree to be interviewed. The second copy is for your records. Thank you very much for your help.

Yours sincerely,

Researcher name: Pamela Kramer Estol

Phone number / email: (647) 209-0289 / pamela.kramer@mail.utoronto.ca
Instructor and Research Supervisor’s Name: Dr. Arlo Kempf
Email: arlo.kempf@utoronto.ca

Consent Form

I acknowledge that the topic of this interview has been explained to me and that any questions that I have asked have been answered to my satisfaction. I understand that I can withdraw at any time without penalty.

I have read the letter provided to me by Pamela Kramer Estol and agree to participate in an interview for the purposes described.

Signature: ________________________________

Name (printed): __________________________

Date: __________________________
Appendix B: Interview Questions

Thank you for participating in this interview for my research study. As I previously informed you, I am a student at the Ontario Institute for Studies in Education at the University of Toronto, completing the Master of Teaching Program. Data from this interview will be used in my final research report on the efficacy of all-girls learning environments on stimulating girls' interest, participation, and achievement in non-traditional fields of study. I would like to remind you that at any point during the interview you have the right to pass, and you also have the right to withdraw your participation in this study at any time. I would like to ask for your consent once again to participate in this study by being interviewed and having your answers tape recorded. Do you have any questions before I begin?

Participant’s background

1) Please tell me about your role as a teacher at your school. First, do you teach in a sex-segregated or co-ed school? Second, do you teach the same group of students every day (one class), or do you teach multiple classes of students? Finally, which subjects do you teach?

2) Please tell me about your students’ attitudes and interests when engaging in math and/or science. Generally, are the female students’ attitudes and interests positive or negative? How do you know?

3) Have you ever and/or always taught an in all-girls school environment, or have you ever and/or always taught at co-ed schools prior to teaching here?
For teachers who have taught at all-girls schools AND at a co-ed school

4) What differences, if any, have you noticed about girl’s attitudes toward math and science when they are learning in an all-girls environment in comparison to in a co-ed environment?

5) Have you ever taught at a school where outreach programs were implemented? If so, were any of these programs about math and/or science? Please describe them.

6) How effective or ineffective do you think these outreach programs were in increasing female students’ interest in math and/or science?

7) What teaching strategies do you use, if any, to stimulate interest in math and/or science among female students?

For teachers who have taught at a co-ed school

8) What differences have you noticed, if any, between male versus female student participation during math and/or science lessons?

For teachers who have taught at a co-ed school

9) In terms of the demographics of senior math and science classes at your school, do you think the population is predominantly female, predominantly male, or evenly male and female?

10) Can you tell me the percentage of female students at your school who have gone on to take math and/or science courses in their senior high school years?