PROMOTING GENDER EQUITY IN ENGINEERING:

AN EXPLORATION OF FEMALE PRE- & POST SECONDARY PARTICIPANT PERCEPTIONS AND EXPERIENCES IN QSEA

by

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Abstract

The underrepresentation of women in certain disciplines in post-secondary engineering education and in the workforce, has been a prevailing issue. Researchers have analyzed this phenomenon over the years and various initiatives that encourage women to pursue and persist in engineering, however, the positive impact of outreach programs on women's perceptions of engineering is not fully understood. The purpose of this research is to explore the experiences of former female high school and university participants in *Queen's Summer Engineering Academy* (QSEA) in order to determine how to promote equitable participation of males and females in engineering programs.

This research is guided by Gender Schema Theory which is used as a lens for understanding how young women perceive an educational path in engineering. Through stratified sampling, 27 former female participants of QSEA were recruited and ranged from ages fourteen to twenty. Participants completed a three-part questionnaire designed to explore their experiences in the program and gain insights about their perceptions of professional women in engineering. For data analysis, descriptive statistics and an inductive analysis was completed.

According to the results, three themes emerged from the study: 1) QSEA provides impetus to interested females to pursue an engineering degree; 2) participants developed a positive perception of the roles of females in engineering; 3) participants suggested desired resources to understand the female engineering experience. Sub-themes reveal that: (a) participants were interested in engineering prior to participating in QSEA, (b) QSEA informed student knowledge of engineering and motivated participants to pursue engineering, (c) participants learned of possibilities for success in an alternative field (d) there is a need for increased female representation in QSEA instructors and participants, and (e) more opportunities

and resources are required to explore the topic of experiences of women in engineering. According to the findings of this research and limitations of the study, future recommendations are made for future work in this area.

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"*The single greatest cause of happiness is gratitude*"

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Chapter 1

Introduction

Introducing the Research

Throughout history, the underrepresentation of women in the fields of science, technology, engineering and mathematics (STEM) has been an ongoing issue. Although women have progressed over the years and are better represented in certain STEM fields, they still remain underrepresented in engineering. Despite comprising of more than half of the Canadian population, less than 13% of women are professional engineers (National Membership Report, 2018). Across Ontario, the number of undergraduate women enrolled in engineering in 2017 was 6612 compared to 25,927 men (National Membership Report, 2018). According to researchers, this phenomenon is due to the numerous barriers which females encounter throughout their academic journey which prevents them from pursuing and persisting in the field (Gayles & Ampaw, 2016; Nicholls et al., 2007; Johnson, 2011; Eccles, 2014; Tellhed, Bäckström, Björklund, 2018; Coyle & Liben, 2016; Eccles, 2014). This glaring gender deficit highlights the need to better understand how to represent women in engineering. Researchers have postulated that in order to address the deficit of women in undergraduate engineering programs and in the workforce, interest in the field should be cultivated within female high school students alongside encouragement to view engineering as a viable career option. One method of cultivating interest and providing encouragement is through successful outreach programs (Reinking & Martin, 2018). However, the impact of outreach programs on young females' perceptions of engineering is still not fully understood (Gayles & Ampaw, 2016; Cheryan, Master & Meltzoff, 2015). By addressing the discrepancy between the number of males and females in engineering through

successful outreach programs, more women can be motivated to pursue engineering thereby diversifying the field and promoting innovation (Reinking & Martin, 2018).

Personal Statement

My personal experiences with undergraduate female engineering students and my own experiences as a science student, has informed my knowledge and sparked my interest in learning more about engineering education. I had many friends who were in the engineering field who would often describe their experiences to me. While some enjoyed the program, others had many problems with it. One reoccurring problem which I heard from many of my friends was that their classes were full of males who they felt intimidated by. Due to the vast majority of students being males, the professors would often use examples that were specified to the interests of males. This further cemented the alienation they were already feeling. As a biology student myself, I never felt alienated as there was a relatively even number of male and female students in my classes. As such, I never felt intimidated to speak up in class or never felt as though professors were directing their lessons to appeal to male students in the classroom. This made me question why engineering had a discrepancy between the number of males and females in university programs while other STEM programs, such as biology, did not. Was it because more males were enrolled in high school physics which allowed them to apply to a post-secondary engineering degree? Was it because young women in high school had a lack of motivation and perceived lower success in engineering? This led me to learn more about the factors that impact young women from joining engineering in post-secondary education. Moreover, it motivated me to listen to the voices of young women who have been through an engineering outreach program to learn whether their participation, positively impacted their thoughts and self-motivation to potentially enter into an engineering discipline.

Purpose and Research Questions

In order to understand the barriers that young women face when choosing to pursue engineering, their voices and experiences must be heard. Studies show that recognizing the factors which influence female participation in engineering outreach programs, will help create more informed policies and practises that will allow for equitable participation of individuals in all engineering disciplines (Wang, 2013). The purpose of this research is to explore the experiences of former female high school and university participants in *Queen's Summer Engineering Academy* in order to determine how to promote equitable participation of males and females in engineering programs. By understanding some of the factors by which a program thrives at attracting participants, actions can be implemented to better represent females in engineering outreach programs across Ontario.

Factors influencing the involvement of women in engineering is a broad issue which encompasses many variables. In this study, we will look specifically at female participant perceptions and outcomes through involvement in *Queen's Summer Engineering Academy* and how their experiences shape their perceptions of and commitment to future career goals.
The following research questions guide this research:

1. What are the experiences of female participants in the program?
2. How does involvement in *Queen's Summer Engineering Academy* inform participants perception of female professionals in engineering?
3. In what ways does involvement in *Queen's Summer Engineering Academy* motivate participants to pursue engineering in the future?

Conceptual Framework

The conceptual framework which guided this research is the Gender Schema Theory (Bem, 1981). According to this cognitive theory, children from a young age learn what is appropriate for their gender and tend to avoid behaviours associated with the opposite gender. Children understand gender schemas through discourse and social practises (Bem, 1981). These behaviors, which are associated to gender-specific roles, are influenced by numerous factors such as: parental expectations, media, social norms and cultural influences. The theory suggests that a child's own understanding of gender, influences the career choices they will make in the future (Martin & Halverson, 1981). As a result, young women often choose gender specific majors to avoid negative stereotypes associated with careers where women exist as a minority, such as engineering (Steinke, 2005).

This theory is applicable to this study by highlighting the oppression that women face in the career choices that they make due to the negative stereotypes that exist, especially for professional females in STEM. Negative preconceived notions about professionals in STEM, affects young women's future aspiration and retention in post-secondary education. However, outreach programs have the ability to combat gender stereotypes by encouraging girls to be active in male dominated fields by prompting interest and increasing participant's self-concept of abilities (Anderson & Gilbride, 2003). Therefore, analyzing the experiences of former female participants in *Queen's Summer Engineering Academy* will determine if and how the program alters young women's perceptions of professionals in engineering and if the program harnesses the ability to build self-confidence, motivation and interest in those who participate.

Chapter 2

Literature Review

The commitment to gender equality and the progression towards equal opportunities for women has grown in Canadian society. The Government of Canada has invested considerable funds to help accelerate the advancement of gender equality. Women's History Month in Canada, occurring in October, also substantiates the support Canada gives for women to join science, technology, engineering, and mathematics (STEM) disciplines with the aim to creating a lasting impact. Women have made great strides over the years by attaining higher levels of education, taking on leadership roles and actively contributing to the growth and success of the Canadian economy. In 1976, only 45.4% of women were in the workforce but by 2017, the number of women in the workforce rose to 61.5%. Despite growth of success of women in STEM in Canada, gender inequalities still remain including in education. In particular, women still remain under-represented in engineering in both university engineering programs and the profession. The following literature review will discuss the barriers that exist for women in engineering programs and how these barriers impact women's retention and success in the field. The literature review will also discuss the importance of initiatives, such as outreach programs, in promoting more women to enroll in engineering.

Although the number of women in engineering courses in Canada has grown steadily over the years, women continue to remain the minority in comparison to men. The proportion of female graduates in engineering programs rose from 14% to 20% from 1992 to 2013, but continues to remain low in comparison to other fields (Statistics Canada, 2016). Despite having the interest and ability to thrive in engineering, women are less likely to pursue mechanical, civil, electrical and aerospace engineering (Hunt, 2015; Gayles & Ampaw, 2016). The

underrepresentation of women in engineering and the unique barriers young women face, has been an extensive topic of research for decades. Numerous research studies have investigated this underrepresentation and have theorized reasons for this outcome which will be presented in this literature review. The following sections will review the overall framework of women underrepresentation in engineering and the importance of equitable participation in engineering programs in Canada.

Thinking About Women in STEM

Researchers have illustrated the idea of women in STEM as a "leaky pipeline" due to the vast number of women dropping out through all stages of their career (Johnson, 2011). Although there is higher percentage of women graduates in STEM degrees compared to men, STEM still remains a male dominated area (Statistics Canada, 2016).

In her *The Missing Half: Girls and Science Education* (1981), Alison Kelly discusses the issue of disparity between the number of males and females in science by explaining how social factors link science to masculinity. This inequality is especially pronounced in engineering and computer science disciplines, but the question that remains is why? Why are women less likely to participate in these fields despite having the capability to persist and thrive in academia and the workforce? Kelly presents the historical notion that the STEM field, especially engineering, is gendered male due to the high population of males joining the field. She emphasizes that the problem with disparity does not lie with women, but the science field itself. Women face complex human generated inequities with the notion that the world of science is clearly a male world. Kelly explains that the image of a scientist and the activities they conduct are perceived as stereotypically masculine. The hypothetical scientist would be seen as an individual who is "objective, independent, logical, ambitious, unaware of the feelings of others and aggressive"

(p.218). This perpetuates the belief that males are better suited for the science field and women are better suited for the arts field. She explains that there is a "vicious circle linking socialisation, schooling, the job market and family responsibilities" (p.3). In order to break the cycle of the masculinization of STEM and give women the opportunities to thrive and combat social barriers that exist, further discourse in needed.

Factors Influencing Young Women's Pursuit of Engineering

In Gayles and Ampaw's (2016) paper on the factors that impact the persistence of young women in science majors, the readers are asked to consider, "To what extent do precollege characteristics, goals, parent socialization factors and college experiences, affect the transfer into or out of a science major?" (p.139). If people were asked this question, some may say that it is internal factors, such as self-motivation, that drives individuals into a career path while others might say it is external forces that affect the decisions students make when choosing a career path. The researchers aimed to investigate both the internal and external influences on the decision-making process of high school women into engineering and science in order to address the severe underrepresentation in the field. Both internal and external factors are not mutually exclusive, but rather impact each other in a meaningful way. Furthermore, the factors described in this literature review do not impact women to the same extent, but to varying degrees. These influencing factors should be held at high value as they articulate the impact on young women on the pursuit of engineering in education. The following sections will expand on these two internal and external factors and the various aspects within them from evidence found in the literature.

Internal Factors Influencing Underrepresentation of Women in Engineering

Motivation and Self-Interest

The first category is termed *internal factors,* which describe how intrinsic factors such as motivation and self-interest, impacts women's decisions to pursue engineering. A study by Nicholls et al. (2007) examined whether self-ratings of mathematics, science and computer ability, affected students' decisions to pursue a post-secondary major in STEM. The study looked at over 12,000 students at two Universities in both STEM and non-STEM courses. The study reported that overall, women rated themselves lower in mathematics and science confidence in comparison to men. As a result, many women who chose not to enter into engineering majors, did so due to their negative self-perception of success in the field. The low self-confidence of young women in mathematics and science courses reflects a greater problem. In Canadian universities, the prerequisite courses for engineering are: grade 12 english, grade 12 chemistry, grade 12 advanced functions, grade 12 calculus and vectors and grade 12 physics. If a student drops out of any one of these core prerequisite courses, it limits the option for advancing into engineering as seen in Figure 1. Therefore, the preparation of mathematics and science courses at the secondary level is one of the most important determinants of whether a student will pursue engineering.

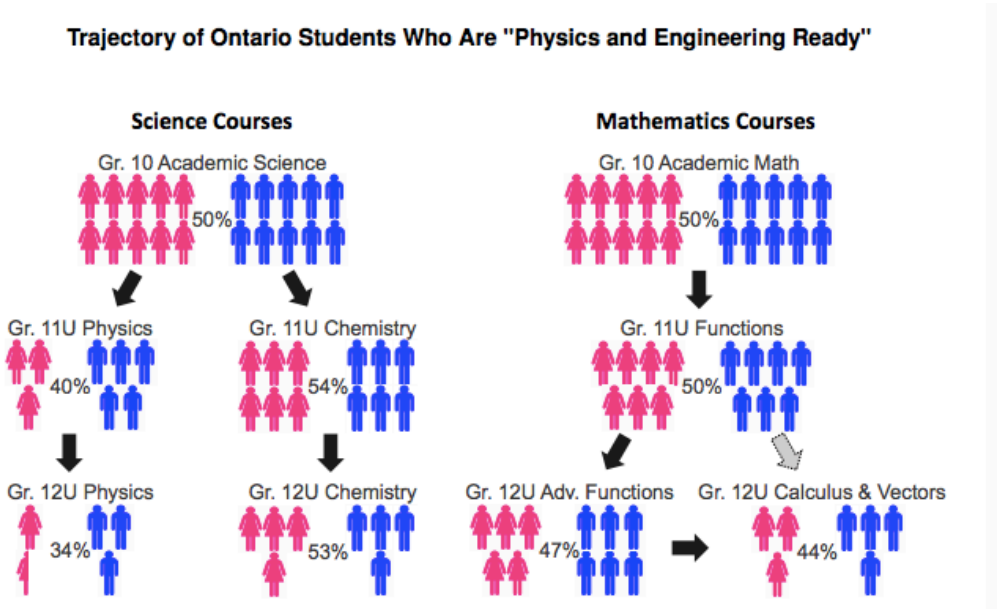

Figure 1. The proportion of male (blue) and female (pink) students enrolled in grade 11 and grade 12 mathematics and science courses. The percentage indicates the rate of female participation in each course (Wells et al., 2018)

The reality is that women have the cognitive ability to thrive in engineering but often lack motivation. Studies of brain structure and function have not shown any significant differences in mathematics and science abilities between gender that would result in the disparity found in engineering (Dasgupta & Stout, 2014). Women perform at par in mathematics and science across all grade levels compared to men despite the social belief that women do not perform as successfully in those subjects (Johnson, 2011; Eccles, 2014). Although lack of self-confidence and motivation is influential in the decision-making process, it can be mitigated through increased resources which introduce young women to opportunities in engineering.

Success in Physics Courses

The "critical point", the point where the greatest number of females are lost in engineering, occurs in physics classrooms. In Canada, the number of female students enrolled in Grade 12 physics is remarkably lower than their male counterparts. In Ontario, only 30% of young women in high school wrote their Grade 12 physics exams in 2008 (NSERC, 2010). Other provinces also showed similar rates of underrepresentation of young women in senior physics courses (NSERC, 2010). This poses as an issue because senior physics courses are a prerequisite for students enrolling into engineering at the post-secondary level. Therefore, with greater loss of young women in high-school physics classrooms, there is a greater loss of women in engineering (Nicholls et al., 2017). Although there has been an increase in enrollment of young women into physics over the last decade, the rate at which women have been enrolling has been slower than other sciences (Hazari et al., 2017). The discrepancy between the number of males and females

in high school physics can be explained in part by young women's negative perceptions of physics and the learning climate of physics classrooms. Research has shown that the ability to see oneself as a physicist in the future, it a strong predictor of whether an individual will enter into the physics and engineering field (Hazari et al., 2017). However, some young women perceive a lack of success associated with physics due to the wrongful belief that they do not inherit the ability to succeed in comparison to men. However, contrary to this belief, research has shown that male and female students have equal aptitude in physics (Nicholls et al., 2017). Another explanation as to why there are a greater number of men enrolled in physics is due to the physics learning environment. According to research by Stadler, Duit and Benke (2000), lesson plans and teaching material can affect women's involvement in physics. For example, if teachers use textbooks which showcase more men than women or use technical examples over social or environmental examples, women may feel like they do not belong. This, in turn, affects their future enrollment into physics and engineering at the post-secondary level (Stadler, Duit and Benke, 2000).

Sense of Belonging

Women's perceptions of how they *belong* in an environment and their views of professionals in the field also influences their decisions to pursue engineering. In order for women to visualize themselves in engineering, their thoughts must align with their perceptions of women in the field (Gayles & Ampaw, 2016). If women perceive engineering as highly masculine and male dominated, they are less inclined to enter the field unless they identify with having more masculine qualities themselves. On the other hand, if women have the confidence to actively contribute to the field and perceive themselves as individuals who belong, they will be more inclined to pursue engineering (Shapiro & Sax, 2011). The influential role that the sense of

belonging has in identifying a career goal can be explained in part through social cognitive theory (Bandura, 1989). An individual with a stereotypical agentic personality, is someone who strives for status, power, assertiveness and respect. On the other hand, an individual with a communal personality is a person with more expressive behavior who is more drawn to helping others. Studies have shown that individuals perceive professionals in engineering as having agentic personalities versus individuals in "people-careers", such as nursing, having more communal personalities (Diekman et al., 2010). Unfortunately, these preconceived notions about professionals in the field, can lead to women succumbing to negative stereotypes therefore affecting their perception of belonging in engineering (Tellhed, Bäckström, Björklund, 2018).

External Factors Influencing Underrepresentation of Women in Engineering

Sociocultural Influence

In addition to the numerous internal factors which influence high school women's selection of engineering in post-secondary education, there are many *external factors* which must also be considered. A factor which impacts women's decisions to pursue engineering is gender socialization through cultural perpetuation. This factor is a commonly held viewpoint across a body of literature. In Western culture, women are stereotyped as being more expressive with their emotions and are pushed to pursue less masculine careers. The careers that they choose should align with their duties as the caregiver of the family according to female gender roles (Coyle & Liben, 2016). Although employment of women has grown to be common in today's society, gender socialization still prevails. This in turn can adversely affect women by preventing them to take on leadership roles and climb up the corporate ladder due to time constraints and lack of motivation (Gayles & Ampaw, 2016).

Socialization also occurs both consciously and unconsciously in family settings. In Eccles's (2014) paper on gender socialization, the researcher conducts an empirical longitudinal study on sixth-graders to uncover family socialization and the impact it would have on the future professions chosen. The study found that although girls were scoring higher than boys in mathematics, parents were supporting their daughters to pursue the arts and english versus mathematics. Their reasoning was that they believed that their daughters were struggling too much in mathematics thus would advance more in an alternative field. Furthermore, the study found that the parents of girls who had high mathematics success, attributed the success more to their efforts rather than their abilities. On the other hand, parents of boys who were successful in mathematics, attributed their success both to effort and abilities. The results concluded that parental beliefs in children, did influence their children's success in mathematics and english. Differences in beliefs of parents for the success of their male and female children, could affect girl's decisions to enrol in mathematics and science courses.

Peer Group Influence

Literature has investigated if and how social influences of peers, effects females' enrollment into STEM courses. In a longitudinal study by You (2011), the researcher worked to identify if a relationship between peer influence and student motivation existed. Using the National Education Longitudinal Survey of 1988, the study looked at: outcome measure, locus of control, students' educational expectation, peer academic value and aspiration for students in the eighth grade. Results from the study showed that the relationship was significant between peer academic value and adolescent school engagement. Students that were motivated by their peers to do well in a course, felt more competent and autonomous versus in courses where there was a lack of peer support. This perceived support, helped students succeed in different courses. On the

other hand, if students believed that male students were more advanced and skilled in mathematics and science while girls were better in English, this belief would negatively affect girls' involvement in STEM courses due to the lack of motivation and perceived success (Eccles, 2014). This outcome of lack of motivation and perceived success, directly overlaps with Gayles and Ampaw's (2016) argument that students' intrinsic motivation and perceptions of natural abilities, influences their decisions to pursue engineering.

In another study by Leaper, Farkas and Brown (2012), the researchers examined social and personal factors related to adolescent girls' motivation in mathematics and science versus english. An ethnically diverse sample of 579 girls aged 13-18 completed questionnaires which measured: parent's education, academic motivation, academic grades, perceived academic support, gender identity, gender-egalitarian beliefs and beliefs of feminism. Results showed a positive relationship between social support in mathematics and science and girls' motivation in the subjects. The results also showed that girls were more likely to be successful in mathematics and science if students supported gender equality and had positive female role models throughout their educational journey. This study further supports the theory that the influence of social factors, has a significant impact in the growth and success of women in science, mathematics and engineering.

Lack of Female Role Models

The lack of women involved in engineering, could be associated with the lack of positive modeling of women in the field. Research analyzing the social barriers which prevent women from joining the STEM field have shown that women who view a career as having a gender imbalance, report lower sense of belonging and less desire to participate (Murphy, Steele and Gross, 2007). Women feel as though they will be more vulnerable to stereotype threat and as a

result, believe that they will have slower advancement opportunities due to the lack of successful female role models in comparison to men. Other studies have also shown that a lack of positive female role models, can lead girls to believe that there is social isolation in a career, such as engineering, thereby deterring their interests (Cheryan, Master & Meltzoff, 2015). However, in the paper by Cheryan et al., (2011), the researchers offers solutions to the problem. The paper highlighted that even a brief interaction with an individual in STEM, can drastically alter a young woman's perception of the field. If young women are given more opportunities to interact with individuals in engineering, they have the opportunity to find similarities in personalities and identify with successful women in the field.

The ways in which women are influenced by both *internal factors* and *external* factors which were not mentioned in the literature review are synthesized here. The literature used in this synthesis addresses the factors influencing young women choosing engineering and the social barriers they face:

- Perception of difficulty in engineering (Glass et al., 2013; Sibley, 2016)
- Stereotype threat (Hackett & Betz, 1981; Dingell & Maloney, 2002; Peters et al., 2012)
- Lack of knowledge on the field of engineering (Anderson & Gilbride, 2003; Crumpton-Young et al., 2010)
- Lack of exposure and real-world experience (Hoobler, Lemmon & Wayne, 2011; Brammer, 2018)
- Lack of self-concept of success (NSERC, 2010; Glass et al., 2013, Singh & Fouad, 2013)
- Lack of equitable learning and assessment (Reis, 2012; Brammer, 2018)

Call for Action

Women have the capacity to make great contributions to engineering but are impeded due to the many barrier they face. To better understand the "leaky pipeline" of women entering engineering in post-secondary education, the number of females in science and mathematics courses at the high school level, must be further investigated. The gender pattern across Canada has shown that the high representation of young women in chemistry and mathematics at the high school level, does not translate into post-secondary education when compared to their male counterparts (NSERC, 2010). In order to understand the path students' take toward post-secondary education in engineering, the number of high school students in mathematics and science courses must be considered. In Ontario, the number of male students who were either enrolled or writing their grade 11 and grade 12 science and mathematics exams were 155 966 versus 146184 female students (NSERC, 2010). This discrepancy between the number of males and females in mathematics and science courses at the high school level warrants a call for action.

Attracting women into the engineering field is important due to constant advancements and the growing need for skilled and competent workers (Gayles & Ampaw, 2016). Without womens' involvement due to inequities and discrimination, the field is deprived of talented individuals who can contribute new perspectives. Occupations in engineering have also shown to be lucrative therefore women miss out on financial career opportunities when either dropping out or choosing not to be involved in the field (Cheryan, Master & Meltzoff, 2015). Thus, incentives to attract and retain female high school students in mathematics and science courses, in an effort to close the gender gap in engineering, must be further explored.

Value of Outreach Programs

Due to the high demand for women in engineering, many educational practises have been implemented to counteract the obstacles that women face. Research has suggested diversifying the image of professional engineers in an effort to attract more women to join the field. Greater representation of professional women in engineering can be accomplished through exposing students to diverse role models, various domains in engineering and through creating a supportive learning community (Cheryan, Master & Meltzoff, 2015). The National Survey of Outreach Programs provides evidence that well-developed outreach programs, have the capacity to promote student success by facilitating areas of learning where schools may be failing (Tierney, Corwin & Colyar, 2005). This, in turn, motivates young women to enroll and continue in their mathematics and science courses at the high school level which opens the opportunity to pursue engineering in the future.

The following collection of factors in Figure 1 represents potential positive outcomes and promotability factors through involvement in outreach programs synthesized from a body of literature.

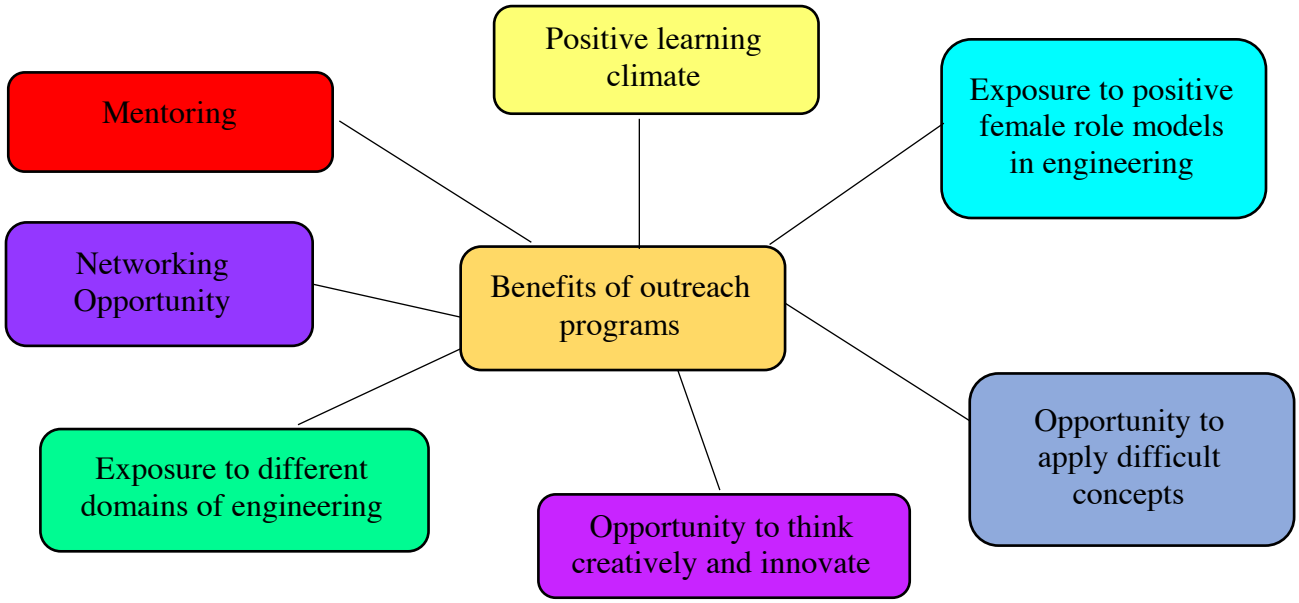

Figure 2. Potential positive outcomes through involvement in engineering outreach programs (Anderson & Gilbride, 2003; Tierney, Corwin & Colyar, 2005; Dasgupta and Stout, 2014; Cheryan, Master & Meltzoff, 2015; Reinking & Martin, 2018)

An example of an outreach program geared towards promoting women to join engineering is *Women in Engineering (*WIE) established by Ryerson University in 1989. The main goal of the program is to help elementary and high school girls perceive the field of engineering as a viable career option. The program also gives girls the opportunity to work on hands-on activities, ask questions and solve engineering-based programs collaboratively thereby building a positive learning community. Girls involved in the outreach program have the opportunity to look at involvement in the program as a hobby unrelated to academics thereby alleviating many associated stressors (Dasgupta and Stout, 2014). A successful program that WIE hosted was the *Discover Engineering* summer camp. The camp introduced positive female role models, confidence building exercises, awareness about career options and information about the importance of engineering in society (Anderson & Gilbride, 2003). Questionnaires and evaluations were administered to the participants both before and after the program to measure success of the program and the impact that the program had on the participants. Follow-up surveys were also conducted two years later to analyze the long-term impact of the program on former participants. As a result, 80% of the participants agreed that the camp increased their knowledge about engineering and 40% indicated that they were interested in pursuing engineering as a career (Zywno, Gilbride, & Gudz, 2000). The program continues to grow in success with an increase in enrollment each year. The WIE committee has upheld the success of *Discover Engineering* through questionnaires, surveys and evaluations of participants as a means to develop into an exemplary program.

Queen's Summer Engineering Academy (QSEA)

Queens University established an engineering outreach program geared towards students of all genders in Grades 9-12 called: *Queen's Summer Engineering Academy*. The program was first established in 2016 and has since grown over the years. The mission of this program is to introduce students to the profession and academics of engineering through workshops, hands-on activities and discussions with students and professionals involved in engineering. Moreover, the program works to inspire the next generation of female engineers. The three mission statements of *Connections Engineering Outreach* are:

1. Provide experiential opportunities for pre-university students to learn about engineering, with an additional focus on increasing diversity within the engineering profession.
2. Develop and share quality engineering education tasks that align with the Ontario K-12 Curriculum
3. Provide support and professional development opportunities for educators looking to integrate engineering and 21st century skills into their practice.
4. Develop positive relationships between the FEAS and the Kingston community.

Although the program has gone through a noticeable success with increasing enrollment each year, the program lacks evidence of the learning experience of all the participants and particularly, of the females in the program and whether their participation provides the resources and motivation to potentially pursue engineering in the future. Thus, the following study will explore the experiences of former female participants in *Queen's Summer Engineering Academy* to determine if and how participation in the program informs their perception of women in engineering and influences their career aspirations. Furthermore, the study will offer insights about how to better recruit females to participate in engineering outreach programs thereby

increasing their representation. By listening and better understanding the experiences of young women in outreach programs, more informed policies and practises can be created that will help build equitable participation of individuals in engineering disciplines (Wang, 2013).

Chapter 3

Research Methods

This chapter will detail the research methodology and methods used in this study. It will also outline the recruitment of participants via email, the items in the questionnaire, data collection and data analysis methods. The questionnaire designed in this study was used to gain an understanding of how the young women who participated in Queen's Summer Engineering Academy (QSEA), view women in engineering and whether the program influenced them in thinking about engineering as a viable career option.

Descriptive Survey and Exploratory Research

This research methodology utilized a non-experimental procedure with a descriptive survey research design to compile information from a sample about a phenomenon through the use of a survey questionnaire (Patton, 2015). An online questionnaire gathered information about young female participants' experiences in QSEA. A descriptive survey research design is well suited for this study as conclusions can be drawn about trends in the population through the responses of the sample. While the questionnaire contained options for participants to choose from on a Likert scale, it also contained three open ended questions where participants had the opportunity to describe their experiences in more detail. The open-ended questions, allowed for participants to share their unique insights about their thoughts about the program, women in engineering and their own ambitions in the field. This allowed for a richer quality of information which further explored the phenomenon in greater detail (Patton, 2015).

Ethics

Prior to conducting the study, ethical clearance was obtained from Queen's University General Research Ethics Board (see Appendix A). Before beginning the questionnaire,

participants were given detailed information in the recruitment email about the topic of the study and what participation would require with an emphasis that participation was completely voluntary. Participants were also informed that confidentially would be preserved to the highest extent possible through encryption of data and storage on a password protected computer. The researcher's and supervisor's contact information was given if any questions or concerns arose regarding the nature of the study.

Methods

Recruitment

Approximately 80 female participants, from 2016-2018, were emailed through Scott Compeau, manager of Connections Engineering Outreach. In the recruitment email, participants were given information which outlined the purpose and details of the study and that their participation would involve describing and reflecting on their experiences of QSEA through a questionnaire. The goal of exploring their experiences would be to determine if it helped shape their understanding of women in engineering and if it increased their knowledge of engineering as a viable educational option. If participants were interested in participating in the study, they would click on the link in the email which would open up the letter of information and questionnaire designed through Qualtrics (see Appendix B & Appendix D).

Sample

The individuals who participated in this study were former female participants of QSEA from 2016-2018 in Ontario. The young women who participated were best fit for this study as they had exposure to being in an engineering outreach program and had personal experiences with participation in QSEA. Through stratified sampling, the 27 female participants who were recruited ranged from ages fourteen to twenty. The requirements for participation in the study

were that respondents would have participated in a program through QSEA from 2016-2018. The respondents included high school students, post-secondary students and those who completed high school but did not pursue post-secondary education.

Survey Instrument and Data Collection

The questionnaire (see Appendix D) was tailored to a population of young women aged fourteen to twenty who participated in QSEA. The questionnaire was only offered in English and contained a total of 18 questions. The questionnaire was divided into three thematic sections. In the first section, demographic and basic information, respondents were asked for their current age, ethnicity, city of residence and education status. Respondents would either input their response or select a single response from a set of predetermined responses.

The second section of the questionnaire delved into participants' experiences in QSEA using Likert scale response to items where participants chose whether they strongly agreed, somewhat agreed, neither agreed or disagreed, somewhat disagreed or strongly disagreed with the prompt. The Likert response categories were kept consistent where the 5 variants were repeated for each question. The questions inquired about: (1) participants interests in engineering, (2) whether the program heightened their interests, (3) whether participants gained helpful resources through the program, (4) whether participation in QSEA informed their knowledge of women in engineering, and (5) whether participation in the program encouraged them to pursue engineering and/or a STEM discipline.

The third section prompted participants to share more about their experiences in more detail through three short answer questions. This gave them the opportunity to explore their experiences at a deeper level as well as elicit insights that may have not been mentioned in the previous two sections thereby providing further valuable perspectives. Participants were

encouraged to think about if and how participation in QSEA encouraged them to pursue engineering, whether it informed their perceptions of women in engineering and how the program could better represent women in the field. The questionnaire was designed to answer the purpose and research questions of the study which aim to understand if and how participation in outreach programs, such as QSEA, acts as a motivational factor and informs young women's perceptions of female professionals in engineering. Participants were given approximately two weeks to complete the online questionnaire which was designed to take approximately 25-30 minutes to complete. The anonymous and confidential data was collected and stored on the Qualtrics survey platform.

Data Analyses

Data analyses occurred in two stages. For the first stage, which included data from sections one and two of the questionnaire, a quantitative analysis was conducted. For section one of the questionnaire, which dealt with demographic and basic data, frequency counts were generated. For section two of the questionnaire, descriptive statistics (frequencies, means, standard deviation, variance and standard variance) were calculated for each question in the questionnaire. Statistical Program for the Social Sciences version 22 (SPSS v.22) was used to compute all descriptive statistics. This was done to determine if QSEA informed participants perception of female professionals in engineering, which addresses research Question 2. Additionally, the quantitative data examined if participation in the program, motivates participants to pursue an engineering or a STEM discipline in the future which addresses research Question 3.

A qualitative analysis was conducted for the next section of the questionnaire which examined the three short answer questions in the questionnaire. An inductive analysis was

chosen as the approach to analyse the data. Literature indicates that an inductive analysis approach is used to: (1) condense data into a meaningful summary, (2) provide links between the study objective and the raw data, (3) develop a theoretical framework according to the data (Thomas, 2006). Through this form of analysis, the phenomenon can be better understood through the multiple interrelated themes that emerge from the data (Patton, 2015). Therefore, an inductive analysis was the best fit method for addressing the research problem and research questions of the study.

Open coding is the process of "breaking down, examining, comparing, conceptualizing and categorizing data" (Strauss & Corbin, 1990, p.61). This analytic process was conducted where codes were given to key terms or phrases to identify noteworthy findings in participant's responses. After open coding, further coding was conducted to refine the results and to search for initial codes in order to create categories (Patton, 2015). Axial codes were then named by for the categories. Lastly, selective coding was done by selecting a core theme which best described the data in the category. All qualitative data analysis was conducted manually through Microsoft Excel spreadsheets.

Ensuring Trustworthiness and Credibility

Trustworthiness is important in a study in order for the findings to be transferable and dependable (Given & Saumure, 2008). Transferability allows for the study to be applied to alternative settings as the data analysis is conducted and analyzed with enough detail. To ensure trustworthiness during the data analysis process, memoing was done. The researcher recorded reflective notes about their own thinking during analysis of participants responses. This was done in order for the researcher to recognize their own subjectivity and personal biases. As a form of

member checking, participants had the opportunity to review the results to ensure that the findings were synonymous with participant's own responses (Given & Saumure, 2008).

Chapter 4

Research Findings

The purpose of this study was to explore the experiences of former female high school and university participants of *QSEA*. Both descriptive statistics and inductive analyses of participant's responses were used to address the following research questions:

1. What are the experiences of female participants in the program?
2. How does involvement in *Queen's Summer Engineering Academy* inform participants perception of female professionals in engineering?
3. In what ways does involvement in *Queen's Summer Engineering Academy* motivate participants to pursue engineering in the future?

The following research findings section is organized into two parts. The first section, quantitative analysis, will detail the descriptive statistics done on participant's questionnaire responses through SPSS. The second section, qualitative analysis, will reveal the codes, categorization of codes and thematic representations of the three short answer questions which participants completed in the questionnaire.

Section 1: Quantitative Analysis- Descriptive Statistics

Demographics. The respondents who participated in this study were 27 former female participants of QSEA. As presented in Table 1, the majority of participants ranged from ages 16-18. Most participants were also Caucasian and resided in Toronto and Kingston. Furthermore, most respondents who participated in the study were senior students and 17 out of the 27 respondents were enrolled in engineering prerequisite high school courses (2 Math, 2 Science, 1 English).

Table 1

Demographics of Former Female Participants of QSEA in the Study (n=27)

Demographic	# of Participants
Current Age	
13-15	4
16-18	21
19-21	2
Ethnicity	
Asian	1
Indigenous	1
Caucasian	22
Other	2
Prefer not to say	1
Current City of Residence	
Vancouver	1
Toronto	7
Mission	1
Mississauga	2
Kingston	6
Richmond Hill	1
Belleville	2
Cambridge	1
Halifax	1
Cornwall	1
Ottawa	1
Brighton	1
Outside Canada	2
Education Status	
Grade 10	3
Grade 11	10
Grade 12	8
Post-Secondary	6
Education Level	
Planning to take high school prerequisite engineering courses (2 Math, 2 Science, 1 English)	4
Currently enrolled in high school prerequisite engineering courses (2 Math, 2 Science, 1 English)	17
Currently enrolled in an engineering program at the college/university level	5
N/A	1

Descriptive statistics were calculated for each question in the questionnaire. The descriptive statistics provided a distribution of participants' responses on the Likert scale for each question. The questionnaire was divided up into six different variables to examine participant's perception of various outcome from participating in QSEA. These variables were: 1) knowledge and interest, 2) helpful resources, 3) women in engineering, 4) self-confidence and self-identity, 5) pursuit of STEM and 6) pursuit of engineering.

Table 2 provides information about participants' overall responses to questions six to fifteen in the questionnaire. Participants were asked to respond to each question using a 5 point Likert scale: 1-strongly agree, 2-somewhat agree, 3-neither agree nor disagree, 4-somewhat disagree, 5-strongly disagree. According to Table 2, the item which most respondents strongly agreed with was that their goal is to pursue a career in science, technology, engineering or mathematics (M=1.07, SD=0.27). Overall, most other items in the questionnaire were rated as 'somewhat agree' and 'neither agree nor disagree.'

Table 2

Descriptive Statistics: Response to Items Overall

Items	**Mean (SE)**	**SD**	**Variance**
I participated in QSEA due to my interest	1.1 (0.06)	0.32	0.10
QSEA increased my insight about engineering	1.52 (0.10)	0.51	0.26
Resources from QSEA were helpful	1.44 (0.10)	0.51	0.26
QSEA informed my perception of women in engineering	2.30 (0.18)	0.91	0.83
Having female role	1.81 (0.18)	0.96	0.93

models encourages me to pursue engineering			
QSEA increases my self-confidence about my abilities in engineering	1.81 (0.16)	0.83	0.69
QSEA increases my self-identity as a woman in STEM	2.11 (0.22)	1.12	1.26
QSEA motivates me to pursue a STEM discipline	1.44 (0.10)	0.51	0.26
QSEA motivates me to pursue engineering	1.44 (0.16)	0.85	0.72
My career goal is to pursue science, technology, engineering or math	1.07 (0.05)	0.27	0.07

As can be seen in Figure 3, 89% of participants strongly agreed that they joined QSEA due to their own interests in engineering. All participants also agreed that the program exposed them to novel insights about engineering which were not known prior to attending the program. From Figure 4, it is clear that all participants agreed that the resources offered through QSEA were informative and helpful at distinguishing the various fields in engineering.

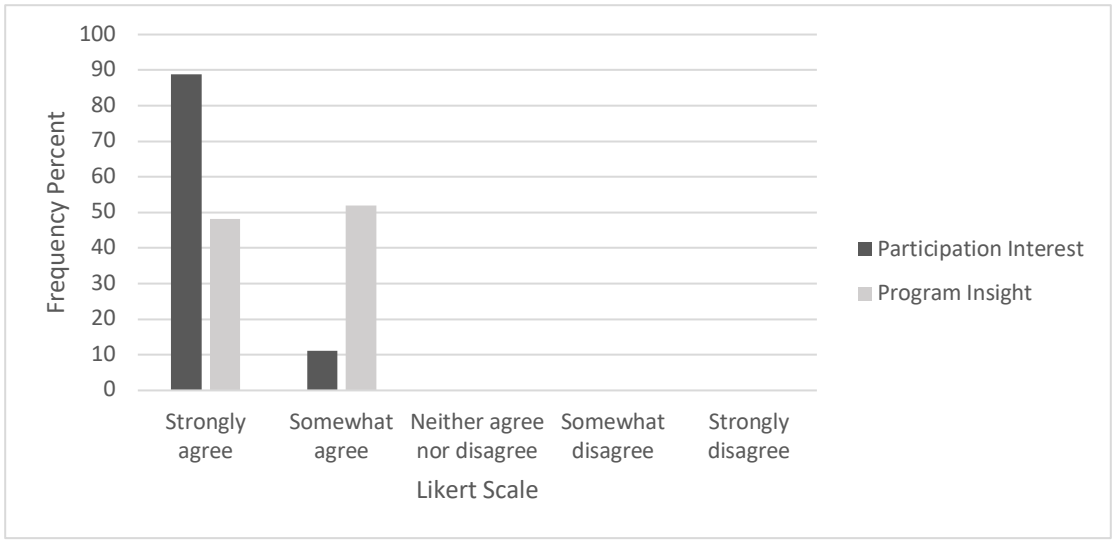

Figure 3. Participants responses addressing whether they joined QSEA due to interest and if the program increased their knowledge about the different fields of engineering.

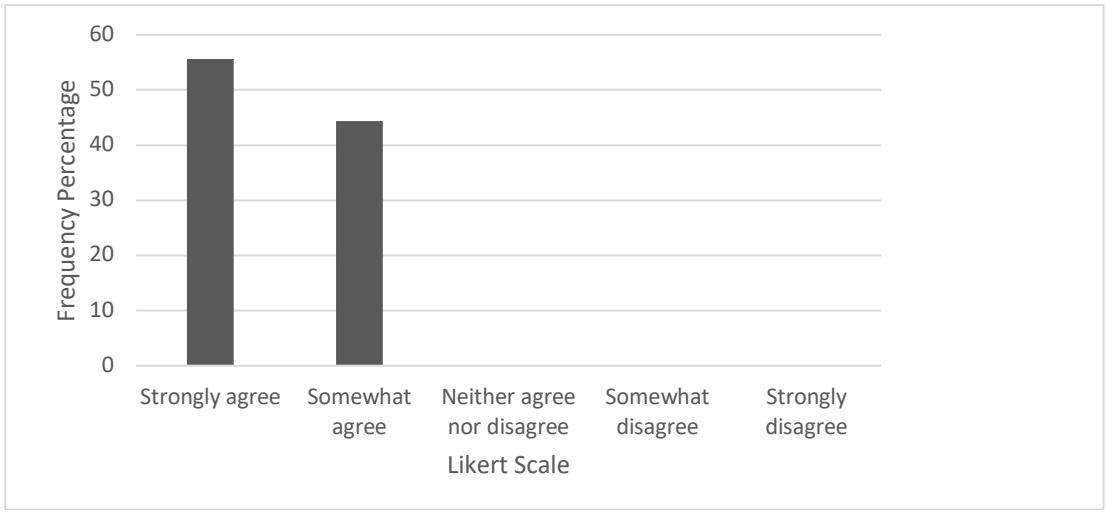

Figure 4. Participants responses about if the resources offered through QSEA were helpful at informing their knowledge about engineering and the various fields within the profession.

According to participants'perception of women in engineering, 56% 'somewhat agreed' that participation in QSEA provided a better understanding of the important role women play as professionals in engineering. Only 15% 'somewhat disagreed' with this statement. Additionally, when participants were asked whether having female role models in engineering run sessions of the program, encouraged them to pursue engineering, 48% 'strongly agreed'. Although the

majority of participants agreed with this statement, 15% ‘neither agreed nor disagreed’ and 7% ‘somewhat disagreed’.

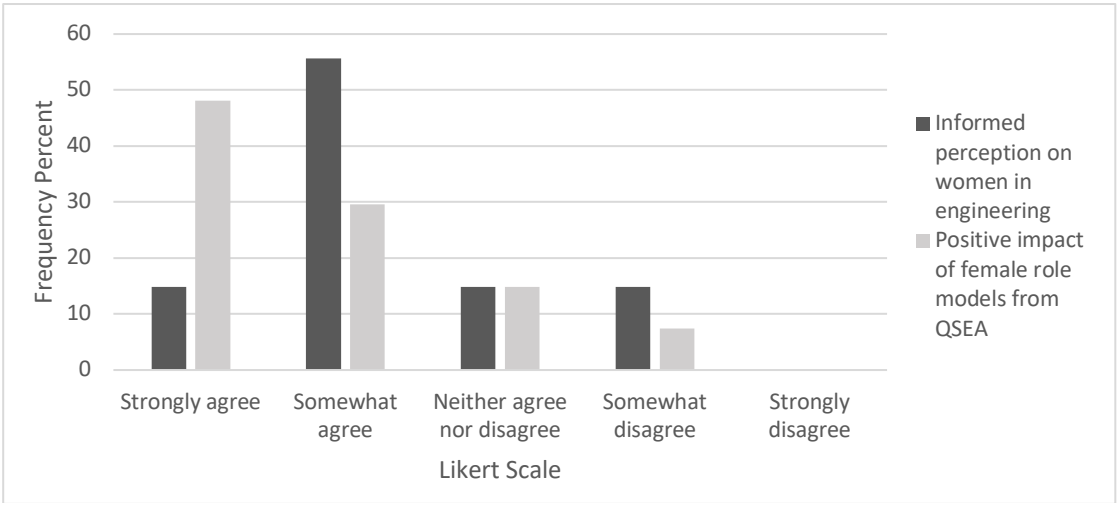

Figure 5. Participant’s responses indicating to what extent QSEA provides a more accurate perception of women in engineering and if having female role models run sessions in the program, acts as a form of encouragement for participants to pursue engineering.

Successful outreach programs work to increase participant’s self confidence in a particular area by exposing them to subject specific content in an engaging way (Cheryan, Master & Meltzoff, 2015). In addition, successful programs allow participants to envision themselves in the field. For participants in QSEA, 37% ‘strongly agreed’ and 52% ‘somewhat agreed’ that participation in the program increased their self-confidence in their abilities in engineering according to Figure 6. With regard to QSEA increasing participant’s self-identity as a woman in STEM, only 37% ‘strongly agreed’ and 22% ‘neither agreed nor disagreed’ with this statement.

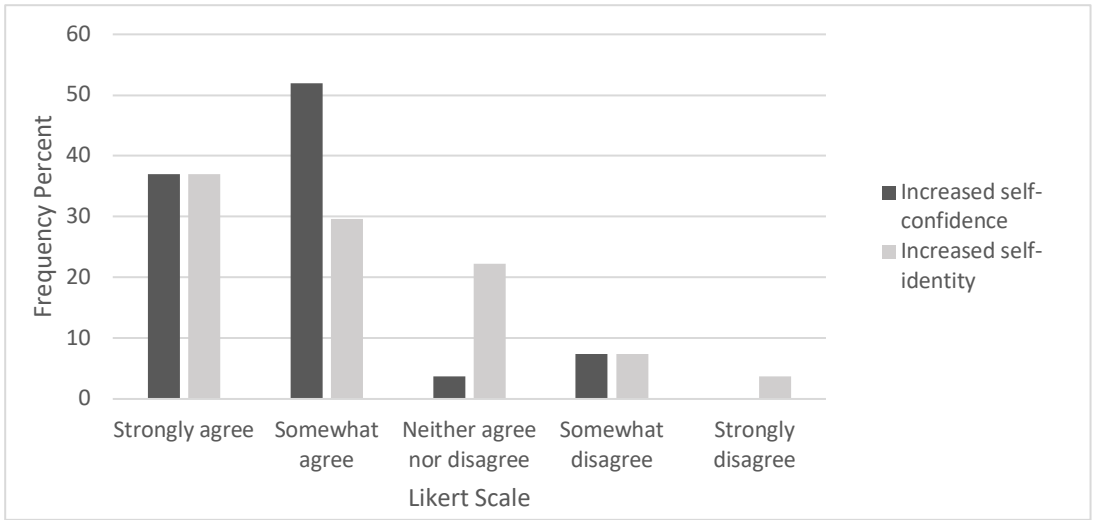

Figure 6. Participant's perceptions of whether participating in QSEA, increases their self-confidence in abilities in engineering and whether participation increases their self-identity as a woman in STEM.

To better understand the lasting impact that QSEA has on participants, they were asked about their future aspirations. In particular, participants were asked whether participation in the program, encouraged them to pursue STEM education. According to Figure 7, 56% of participants 'strongly agreed' while 44% 'agreed'. Most participants also 'strongly agreed' that they plan to pursue a career in STEM in the future and that participation in the program acts as a motivational factor. When looking specifically at participant's future aspirations in engineering, 70% 'strongly agreed' that the program motivates them to pursue an engineering discipline while only 7% 'somewhat disagreed' according to Figure 8.

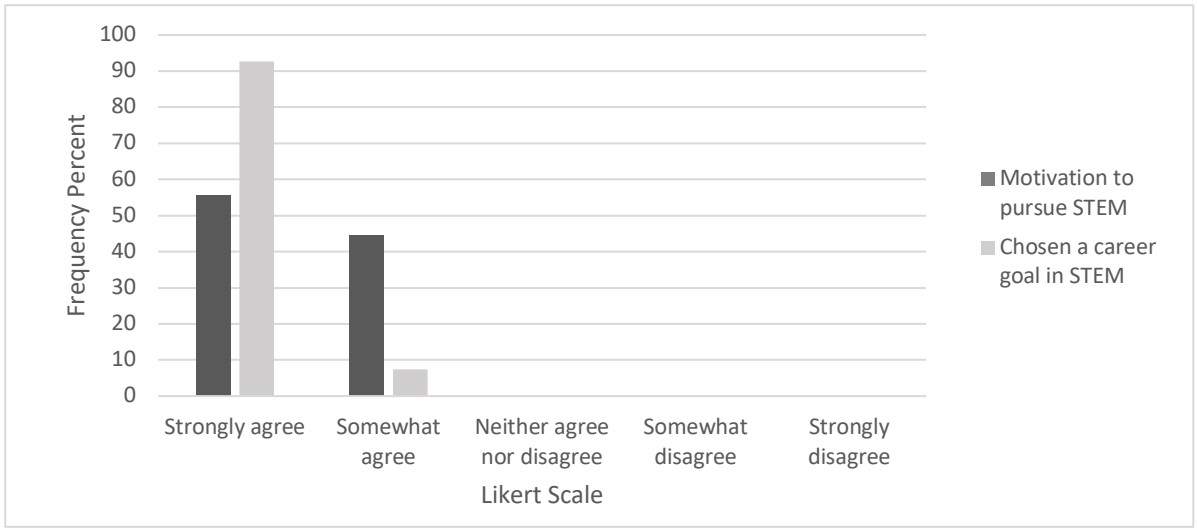

Figure 7. Participant's perceptions of whether participating in QSEA, motivates them to pursue a STEM discipline and whether their future aspiration is to pursue a career in STEM.

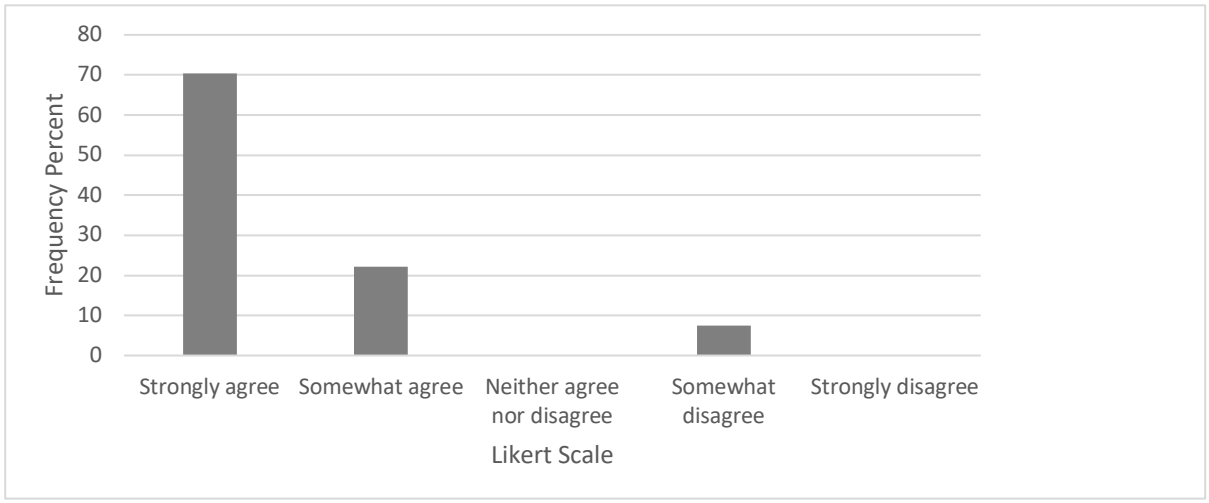

Figure 8. Number of participants who believe that participation in QSEA, motivates them to pursue an engineering discipline.

Section 2: Qualitative Analysis- Inductive Analysis

The following three themes emerged from the data: 1) QSEA provides impetus to interested females to pursue an engineering degree; 2) participants developed a positive perception of the roles of females in engineering; 3) participants suggested desired resources to understand the female engineering experience.

Thematic Representation of the Results

Theme 1: QSEA provides impetus to interested females to pursue an engineering degree

In the questionnaire, participants were asked if and how their experiences in QSEA, influenced them to pursue an engineering degree. Three sub-themes emerged from their responses: (1) participants were interested in engineering prior to participating in QSEA, (2) QSEA informed student knowledge of engineering and motivated participants to pursue engineering and (3) participants learned of possibilities for success in an alternative field. The majority of respondents (17 of 27) said that the program increased their knowledge on engineering and exposed them to the various disciplines within the field thereby allowing them to identify which disciplines appealed to them. This in turn, motivated them to continue to be involved in the program and to pursue an engineering degree, especially at Queen's University. According to one participant, "QSEA exposed me to the different fields and opportunities within engineering, and as a result helped influence my decision to pursue engineering". Eight out of the 27 respondents stated that they were interested in engineering prior to attending the program but that involvement in QSEA reaffirmed their aspirations to pursue engineering. As one participant said, "I had a strong interest in engineering before I participated in QSEA, but the program helped me identify which engineering disciplines I want to learn more about". Similarly, another participant responded, "It was my interest in engineering that lead me to

participate in QSEA originally, but participating in it did make me feel more confident in my decision as I began to have a sense of the expectations of a university level engineer".

Some participants (2 of 27) felt that involvement in QSEA helped them realize that engineering did not align with their own interests and future aspirations. One participant responded saying, "Seeing what different types of engineers do on a daily basis made me realize that I prefer the pure sciences and mathematics as opposed to applied sciences. While I found the engineering-design process valuable and appreciate the problem-solving skills that QSEA gave me, I've since participated in mathematics programs and decided that I would like to pursue a career in math".

Theme 2: Participant's developed a positive perception of the roles of females in engineering

Participants were asked if and how involvement in QSEA, informed their perceptions of women in engineering. The majority of respondents (21 of 27) stated that the program did inform their perceptions. Many stated that having female instructors run sessions, helped them envision women in engineering thereby acting as a motivational factor. One participant stated that having female instructors expose her to the various opportunities in engineering, made her more excited at the prospect of choosing an educational path in the field. Similarly, another participant stated that having the opportunity to talk to friendly female instructors, made her comfortable to ask questions regarding their positive experiences in engineering which encouraged her to believe that she could succeed in engineering too. Some participants also mentioned that the gender disparity between males and females in engineering was discussed with participants through instructors which allowed them to better understand the importance of female involvement in the field. As one participant stated, "My experience in QSEA helped confirm the extensive gender

gap within engineering; there are more women and girls interested in the field but it is still male dominated". Prior to the program, many participants stated that they were unaware that women existed as a minority in many disciplines in engineering. QSEA instructors discussed this discrepancy by informing participants about this issue but also explained that more women were joining the field which, as a result, was slowly decreasing the gender gap. One participant responded saying, "I learned that STEM is becoming a more gender balanced field, as opposed to the male dominated field that I thought it would be. It gave me more confidence in my ability to succeed in a STEM field".

While some participants perceptions of women in engineering were informed through discussions with female instructors, other participant's perceptions were informed differently. A few participants (4 of 27) stated that they noticed a striking difference between the number of boys and girls participating in QSEA and also in the number of male and female instructors. One participant even noticed a pattern of fewer female instructors in certain disciplines, such as chemical engineering, which she believed was "expected" due to the gender disparity present in the field. Another participant went on to say,

> "My experience at QSEA was slightly discouraging when informing my perception of women in engineering, because there were very few girls as compared to boys in the program. This was disheartening and made me feel like there weren't very many opportunities for women in engineering. If the proportion of boys to girls at QSEA was representative of most engineering workplaces, I would not pursue a career in engineering because I would not enjoy that type of environment".

Other participants also talked about feeling "intimidated" and "uncomfortable" due to being the only girl in a group during group activities. In this way, their perceptions of women in

engineering were informed differently when compared to the other participants. A few participants (six of 27) did not feel as though the program informed their perceptions on women in engineering as they had no exposure to this topic and/or did not view women as being limited in engineering and STEM.

Theme 3: Participants suggested desired resources to understand the female engineering experience

When asked what could be improved about QSEA to better represent women, two sub-themes were derived from participant's responses: 1) there is a need for increased female representation in QSEA instructors and participants and 2) more opportunities and resources are required to explore the topic of experiences of women in engineering. Seven of 27 respondents did not feel as though any improvements were needed as they felt that women were well represented in QSEA. Some felt that having female instructors run sessions, helped them feel more confident and comfortable in their work. On the other hand, other participants felt a lack of both female instructors and participants. One participant stated, "It would be good to have more female leaders and participants. It would have really got my attention if there had been a close to equal number of male and female participants". Many respondents mentioned that having female guest speakers such as: graduate engineering students, alumni engineering students, professors and experts in the field, hold seminars and workshops, would help them envision professionals in the field. The importance of "understanding experiences" was mentioned numerous times in participant's responses as an important factor in understanding the lives of female engineering students and professionals. Therefore, an increased number of female instructors, guest speakers, and participants was suggested to better represent women in engineering through QSEA.

While some participants believed that increasing the number of female instructors running sessions would better represent women in the program, others felt that resources offered in QSEA could be improved. One participant mentioned, “I feel that maybe having a separate activity during the program where the female mentors can talk to the girls about their experience as a woman in STEM and how they have handled situations where they felt being a woman put them at a disadvantage, would be very beneficial and would help girls learn how to handle such situations”. Another participant mentioned that “discussing notable female engineers and/or their accomplishments” would encourage them and would in turn, better represent women in engineering.

These three open response questions in the questionnaire were intended to better understand female participant’s experiences in QSEA. Additionally, the questions aimed to shed light on participant’s own perceptions of women in engineering and if and how involvement in QSEA acted as a motivational factor for them to pursue the field.

Chapter 5

Discussion

The purpose of this research was to explore the experiences of former female high school and university participants in *Queen's Summer Engineering Academy* (QSEA) in order to determine how to promote equitable participation of males and females in engineering programs. Using self-reported data, this research was guided by the following research questions which looked specifically at the outcomes of participating in QSEA:

4. What are the experiences of female participants in the program?
5. How does involvement in *Queen's Summer Engineering Academy* inform participants perception of female professionals in engineering?
6. In what ways does involvement in *Queen's Summer Engineering Academy* motivate participants to pursue engineering in the future?

This study utilized both quantitative and qualitative research methods. The sample consisted of 27 former female participants of QSEA. To address the research questions, a questionnaire was administered to participants which inquired about their experiences in QSEA as well as their perceptions of women in engineering. After participant's responses were collected through Qualtrics, descriptive statistics were completed for respondent's demographic information and for participant's responses derived from a Likert scale. An inductive analysis was subsequently completed for the three open response questions in the questionnaire.

This chapter is organized into three sections. The first section summarizes key research findings in relation to the research questions of this study. The second section discusses future recommendations for work in this field. Lastly, the third section considers limitations of this research.

Key Findings

Research Question 1: What are the experiences of female participants in the program?

The purpose of the first research question was to explore the experiences of former female participants of QSEA in order to understand how the program influenced their perceptions of engineering. Results from Table 2 showed that overall, most participants agreed that the program increased their insights about engineering and offered them useful resources. The program also increased their self-identity as a woman in STEM. Participant's elaborated on their experiences based on data represented in *Theme 1: QSEA provides impetus to interested females to pursue an engineering degree* and, *Theme 3: Participants suggested desired resources to understand the female engineering experience*. Participants explained that the program informed them about the various disciplines in engineering which helped them to distinguish which areas they were interested in. Research has shown that diversifying the image of engineering, such as through informing participants about the various disciplines that exist, encourages participants to enroll in an engineering program in the future (Cheryan, Master & Meltzoff, 2015). Having the program setting at Queen's University also helped participants envision themselves as university students and understand the expectations of students at the post-secondary level.

Although the majority of participants had a positive experience with involvement in QSEA, many of them suggested improved resources that would help enhance their experiences and the experiences of prospective female participants. A common suggestion across many responses was the need for more female mentors and role-models. Having more female mentors involved in the program opens the opportunity for participants to share their experiences, ask questions, as well as listen to the experiences of individuals who have gone through an

educational path in engineering. Another suggestion which many participants gave was to hold more seminars and workshops where participants are able to learn more about the lives of professionals in engineering and better understand the importance of increased female involvement in the field. Improving the resources in QSEA to enhance the experiences of participants is an important area to improve as research has shown that mentoring, positive learning climate and networking opportunities are positive outcomes that come from involvement in successful outreach programs (Anderson & Gilbride, 2003).

Research Question 2: How does involvement in Queen's Summer Engineering Academy inform participants perception of female professionals in engineering?

The second research question focused on how participants view female professionals in engineering and whether their views were informed after participating in QSEA. Overall, the majority of participants agreed that QSEA informed their perceptions of women in engineering. Prior to the program, many participants were unaware that a discrepancy existed between the number of males and females in certain disciplines in engineering. In the open response statements given by participants, some discussed what they learned about the gender imbalance in engineering and that they felt it was very important to strive for gender balance in the field. Although some participants mentioned that QSEA did address this issue by having discussions on the topic, others also mentioned that the topic was not examined in enough detail and that further discussion was needed. As mentioned earlier, based on data represented in *Theme 3: Participants suggested desired resources to understand the female engineering experience*, participants suggested that more workshops and activities would better inform their knowledge on female professionals in engineering. Participants also suggested that having more guest speakers such as: graduate engineering students, alumni engineering students, professors and

experts in the field, would allow for participants to better understand the role of female professionals in engineering. Influential guest speakers are an important factor to consider as research has shown that exposure to positive female role models in a field, increases interests and considerations as a viable career option (Hagedorn & Tierney, 2002). Research has also shown that a having a positive interaction with a professional in the STEM field who the participant identifies with, enables them to envision themselves as a future professional in the field (Cheryan, Master & Meltzoff, 2015).

According to data represented in *Theme 2: Participant's developed a positive perception of the roles of females in engineering*, many participants felt that their knowledge on females in engineering was increased by the female leaders in QSEA. Having female leaders run sessions in the program was encouraging for participants. However, many participants believed that a greater representation of female leaders was needed due to the disproportional number of males and females. Some participants also expressed concerns over the striking difference between the number of boys and girls participating in the program. One participant mentioned that she feared that the engineering profession would have a similar representation of males and females as was present in the program. The fear of social isolation, stereotype threat and slower advancement opportunities for a woman in STEM due to the gender imbalance in the profession, can lead to a lower desire to enter the field (Murphy, Steele and Gross, 2007). Better representation of women in QSEA, both in the number of leaders and participants, is needed in order to foster a positive learning climate to encourage young women in QSEA to pursue engineering.

Research Question 3: In what ways does involvement in Queen's Summer Engineering Academy motivate participants to pursue engineering in the future?

The third research question examined the effects QSEA had on participant's long-term goals and future aspirations. Results showed that participants somewhat agreed that QSEA increased their self-confidence in their abilities in engineering. When participants were asked what their future aspirations were, the majority of participants strongly agreed that they were planning to pursue an education and career in STEM while a portion of participants stated that they would be pursuing engineering. Many participants explained that they were interested in engineering prior to participating in QSEA, but that the program reaffirmed their interests and goals to pursue engineering as can be seen in the data from *Theme 1: QSEA provides impetus to interested females to pursue an engineering degree*. From participant's own experiences and experiences from participating in the program, their self-interest and motivation was increased thereby increasing their self-perception of success in STEM which is a crucial factor when choosing a career path (Nicholls et al., 2007).

While some felt more motivated to pursue engineering from participating in QSEA, other participants realized that engineering did not align with their own interests. One participant elaborated by saying that she felt that alternative careers in STEM were more gender balanced and that she felt more comfortable pursuing such fields. Other participants mentioned feelings of being "uncomfortable" and "intimidated" in male dominated groups. Although it was not clear whether feelings of discomfort due to the gender imbalance in the program deterred some participants interests in engineering, it did impact their sense of belonging in the program. Research has shown the importance of women having a strong sense of belonging, especially in male dominated fields, in order to be successful and combat the adversities they may face (Shapitro & Sax, 2011). Thus, building a sense of community and peer support is important in

order to counteract any feelings of isolation that young women are facing in QSEA (Peters et al., 2012).

Conclusion

The study's results provided evidence of the impact QSEA had on female participant's perception of engineering and how involvement in the program, provided hope for women to be active in the engineering field. The purpose of the study was to explore the experiences of former female high school and university participants in QSEA in order to determine how to promote equitable participation of males and females in engineering programs. The scope of this study included 27 former female participants who shared their experiences with involvement in the program. The questionnaire provided answers with regard to their experiences in QSEA, how it informed their perception of female professionals in the field and if and how the program motivates them to pursue engineering. The results highlighted the importance of positive peer influence, female role models, access to helpful resources and diversifying the image of engineering in impacting participant's educational aspirations to pursue engineering. The results supported numerous studies indicating the importance of positive experiences and support in increasing the self-confidence and motivation of young women to pursue an engineering degree (Shapitro & Sax, 2011; Cheryan, Master & Meltzoff, 2015; Anderson & Gilbride, 2003). This study provides insights into women's perception of engineering and how developing and improving an outreach program, has the capacity to shape the way women view engineering.

Implications for Future Work

The findings of this study explore perceptions of the gender gap in engineering as well as the effects that outreach programs have on female participant's perceptions of the field. It has significant implications in the area of young women's educational advancements within

engineering. This research contributes to a greater body of literature which outlines the barriers women and the positive impact that well-developed outreach programs can have on their self-confidence, motivation and self-concept of an individual aspiring to apply to a post-secondary engineering program. There still exists a lack of female engineers in certain disciplines in academia therefore discovering solutions to encourage women into engineering is vital (Cheryan, Master & Meltzoff, 2015). By listening to the voices of former female participants and understanding how QSEA affects their views of engineering as a viable educational option, effective improvements can be made to increase the representation of women in outreach programs.

This study provides a platform for future work in the area of exploring the effects of outreach programs on women's perceptions of engineering education. The respondents in the study who participated in QSEA should be followed through to determine if they persisted in QSEA and if their thoughts about engineering changed over the course of a few years. Following up with participants about their thoughts and experiences in the program, provides valuable information pertinent to making changes and improvements to QSEA. This can be accomplished through questionnaires, follow-up surveys and interviews which will allow participants to share their experiences at a deeper level (Anderson & Gilbride, 2003). An extension to this research would also be to explore how cultural influence and socioeconomic status affects female participant's pursuit of engineering. In addition to exploring participant's experiences, consulting with key stakeholders in QSEA is important in order to determine if and how the program is evolving based on recommendations and feedback given by instructors and participants. Through ongoing research on this topic, many important contributions can be made that will change the

way women view engineering through involvement in outreach programs and will thus encourage them to advance in engineering programs.

Limitations

Findings from this study emerged from 27 female respondents from QSEA who completed the online Qualtrics questionnaire. This small sample size and single focus on participants from QSEA, limits the scope of generalizability of findings to other outreach programs at other institutions. The thoughts and experiences that participants described in this study may not coincide with other participants experiences in QSEA and in other existing engineering outreach programs. Another limitation to this study was that all data was derived from a single questionnaire. Although participants had the opportunity to elaborate on their experiences in greater depth in the three short answer questions, participants may have still been limited in what they could share due to the direction of the questions being asked. Having a follow-up interview where participants have the opportunity to openly describe their experiences in greater detail would have been beneficial for this study. Lastly, eliminating the opportunity for boys to share their experiences of participating in QSEA, could be considered a limitation because this research works towards promoting equitable participation of both males and females in engineering. Moreover, male participants may have their own unique insights about women in engineering that could contribute to understanding how to promote female involvement in the field.

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Appendix A: GREB Clearance Letter

November 26, 2018

Miss Angela Joseph
Master's Student
Faculty of
Education Queen's
University Duncan
McArthur Hall
511 Union Street West
Kingston, ON, K7M 5R7

GREB Ref #: GEDUC-935-18; TRAQ # 6025279
Title: "GEDUC-935-18 Queen's Summer Engineering Academy: Encouraging Young Women to Pursue Engineering"

Dear Miss Joseph:

The General Research Ethics Board (GREB), by means of a delegated board review, has cleared your proposal entitled **"GEDUC-935-18 Queen's Summer Engineering Academy: Encouraging Young Women to Pursue Engineering"** for ethical compliance with the Tri-Council Guidelines (TCPS 2 (2014)) and Queen's ethics policies. In accordance with the Tri-Council Guidelines (Article 6.14) and Standard Operating Procedures (405.001), your project has been cleared for one year. You are reminded of your obligation to submit an annual renewal form prior to the annual renewal due date (access this form at http://www.queensu.ca/traq/signon.html/; click on "Events;" under "Create New Event" click on "General Research Ethics Board Annual Renewal/Closure Form for Cleared Studies"). Please note that when your research project is completed, you need to submit an Annual Renewal/Closure Form in Romeo/traq indicating that the project is 'completed' so that the file can be closed. This should be submitted at the time of completion; there is no need to wait until the annual renewal due date.

You are reminded of your obligation to advise the GREB of any adverse event(s) that occur during this one-year period (access this form at http://www.queensu.ca/traq/signon.html/; click on "Events;" under "Create New Event" click on "General Research Ethics Board Adverse Event Form"). An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a substantial change in approach to a participant(s). You are also advised that all adverse events must be reported to the GREB within 48 hours.

You are also reminded that all changes that might affect human participants must be cleared by the GREB. For example, you must report changes to the level of risk, applicant characteristics, and implementation of new procedures. To submit an amendment form, access the application by at http://www.queensu.ca/traq/signon.html; click on "Events;" under "Create New Event" click on "General Research Ethics Board Request for

the Amendment of Approved Studies." Once submitted, these changes will automatically be sent to the Ethics Coordinator, Ms. Gail Irving, at University Research Services for further review and clearance by the GREB or Chair, GREB.

On behalf of the General Research Ethics Board, I wish you continued success in

your research.

Sincerely,

Dean Tripp,
Ph.D. Chair
General Research Ethics Board

c: Dr. Alana Butler, Supervisor
Mr. Scott Compeau, Consultant
Dr. Benjamin Bolden, Chair, Unit REB Mrs. Erin Rennie, Dept. Admin.

Appendix B: Letter of Information and Consent Form

Queen's Summer Engineering Academy: Encouraging Young Women to Pursue Engineering

Research conducted by: Angela Joseph, MEd student, Faculty of Education, Queen's University
Under the supervision of: Dr. Alana Butler, Faculty of Education Queen's University

LETTER OF INFORMATION/CONSENT FORM

Background information
My name is Angela Joseph and I am a MEd student. My background is in mathematics and science education. I want to see how I can help promote the involvement of women in the engineering field through analyzing Queen's Summer Engineering Academy. I would like to explore the experiences of the young women who have partaken in the program to determine if it helped increase their knowledge of engineering as a viable career option.

What participation requires
Participant will partake in an online questionnaire comprising of 18 questions which will inquire about their perceptions of women in engineering and their experiences in Queen's Summer Engineering Academy. The survey will take approximately 25-30 minutes to complete and can be completed at their own convenience.

Voluntary participation
Your participation is completely voluntary. There are no known physical, psychological, economic, or social risks associated with this study. Further, the participant is free to choose, without reason or consequence, to refuse to answer any questions at any time. Participants may also withdraw from the study at any point.

Confidentiality and data storage
I will ensure that participant's confidentiality will be preserved to the highest extent possible. No identifying information will be used in the publication. If I use quotes when presenting my findings, I will do so without real names. All data will be encrypted and electronically stored on a password-protected computer for five years and will then be destroyed. Only I, the primary researcher, will have access to the raw data. Overall findings of the study will be shared with QSEA and Scott Compeau, Manager of Connections Engineering Outreach, who will then disseminate the information to his organization. All data shared with QSEA and Scott Compeau will be anonymized.

Further information
Participation in this study will allow for participant's experiences to inform educational progress in Canada. Also, just by participating, participants will have the opportunity to reflect upon their own self-concept and whether they feel they will pursue engineering in the future.

If you have any further questions about my research, please contact me, Angela Joseph, at angelajjoseph@gmail.com or my supervisor, Dr. Alana Butler, at alana.butler@queensu.ca or at 613-533-6000 ext. 75298.

If you have any concerns regarding the ethical nature of this study, please contact the General Research Ethics Board (GREB) at 1-844-535-2988 (Toll free in NA) or chair.GREB@queensu.ca.

I have read and understood the request to participate in this study on Queen's Summer Engineering Academy.

Name of Participant: _____

Name of Parent/Guardian: (For participants 18 years and under):
_____

Parent/Guardian Signature: _____

Date: _____

Appendix C: Recruitment Script

Queen's Summer Engineering Academy: Encouraging Young Women to Pursue Engineering

Research conducted by: Angela Joseph, MEd student, Faculty of Education, Queen's University
Under the supervision of: Dr. Alana Butler, Faculty of Education Queen's University

Dear Participant and Guardian,

My name is Angela Joseph and I am a graduate student in the Master of Education program at Queens University. I am conducting a research study to understand female views of the engineering field through analyzing Queen's Summer Engineering Academy. I would like to explore the experiences of the young women who have partaken in the program to determine if it helped increase their knowledge of engineering as a viable career option.

Through Scott Compeau, Manager of Connections Engineering Outreach, I am recruiting individuals to participate in a brief questionnaire about their experiences in Queen's Summer Engineering Academy (QSEA) using Qualtrics which will take approximately 25-30 minutes. All data will be encrypted and electronically stored on a password-protected computer for five years and will then be destroyed.

Your participation is completely voluntary. If you have any further questions about my research, please contact me, Angela Joseph, at angelajjoseph@gmail.com or my supervisor, Dr. Alana Butler, atalana.butler@queensu.ca or at 613-533-6000 ext. 75298.

Thank you for your time and participation.
Kind Regards,
Angela Joseph

Appendix D: Questionnaire

Completed in Qualtrics

	Questions	Please provide your answers
	DEMOGRAPHICS	
1	Current age	Choose from: 13, 14, 15, 16, 17, 18, 19, 20, 21
2	Ethnicity	African Canadian, Hispanic, Asian, Indigenous, Caucasian, Other, Prefer not to say
3	Current City of Residence	_____
4	Education Status	Choose from: Grade 10, Grade 11, Grade 12, higher education, N/A
5	Education	Choose from: Planning to take high school prerequisite engineering courses (2 math, 2 sciences, 1 english), Currently enrolled in high school prerequisite engineering courses (2 math, 2 sciences, 1 english), Currently enrolled in an engineering program at the college/university level, N/A
	Queen's Summer Engineering Academy	
ITEMS	Please provide your responses to the questions below using the following scale: 1- Strongly Agree, 2- Agree, 3- Neutral, 4- Disagree, 5- Strongly Disagree	
6	I participated in Queen's Summer Engineering Academy because of my interest in engineering	
7	Queen's Summer Engineering Academy exposed me to aspects of engineering which I did not know prior to attending the program	
8	The resources in Queen's Summer Engineering Academy were helpful in informing my knowledge on engineering and the different fields in engineering	
9	Queen's Summer Engineering Academy provides me with a more accurate perception of women in engineering	
10	Having female role models in engineering run sessions in the program encourages me to pursue engineering	
11	Participating in Queen's Summer Engineering Academy increases my self-confidence in my abilities in engineering	

12	Participating in Queen's Summer Engineering Academy increases my self-identity as a woman in STEM

Future Aspirations

ITEMS	Please provide your responses to the questions below using the following scale: 1-Strongly Agree, 2- Agree, 3- Neutral, 4- Disagree, 5- Strongly Disagree
13	Participating in Queen's Summer Engineering Academy, motivates me to pursue a STEM discipline
14	Participating in Queen's Summer Engineering Academy, motivates me to pursue an engineering discipline
15	My career goal is to pursue a career in science, technology, engineering or math

Open Response Questions

16	Did the experience of participating in Queen's Summer Engineering Academy influence you to pursue engineering?
17	How did your experience in Queen's Summer Engineering Academy inform your perception of women in engineering?
18	If you could improve something about the program to better represent women in engineering, what would it be?