-

MPC MAJOR RESEARCH PAPER

Shifting Gears:
The Impact of Extracurricular Exposure on Girls' Attitudes Towards Engineering

MIRI MAKIN

Dr. Jean Mason

The Major Research Paper is submitted
in partial fulfillment of the requirements for the degree of
Master of Professional Communication

Ryerson University
Toronto, Ontario, Canada

August 14th, 2014

AUTHOR'S DECLARATION FOR ELECTRONIC SUBMISSION OF A MAJOR RESEARCH PAPER

I hereby declare that I am the sole author of this Major Research Paper and the accompanying Research Poster. This is a true copy of the MRP and the research poster, including any required final revisions, as accepted by my examiners.

I authorize Ryerson University to lend this major research paper and/or poster to other institutions or individuals for the purpose of scholarly research.

I further authorize Ryerson University to reproduce this MRP and/or poster by photocopying or by other means, in total or in part, at the request of other institutions or individuals for the purpose of scholarly research.

I understand that my MRP and/or my MRP research poster may be made electronically available to the public.

ABSTRACT

This paper explores the impact of Ryerson's WEMADEIT Youth Think Tank (YTT) on participating girls' understanding of and attitudes toward engineering. According to recent research, most teens openly admit that they are not familiar with the specifics of a job in engineering (Intel, 2011), typically associating the field of engineering with independent work and a math and science focus; however, the Canadian Engineering Accreditation Board (CEAB) emphasizes teamwork, socially-conscious thinking and entrepreneurship. Existing professional engineering organizations, including Engineers Without Borders (EWB), are also working to introduce the broader concept of the "Global Engineer" – a socially and ethically conscious, teamwork-driven, creative engineer. These recent trends in engineering reveal a disparity between public perception of engineering and the realities of the industry. The WEMADEIT project was formed in order to increase girls' interest in and exposure to engineering in three ways: by creating a brand that correlates with new trends in engineering; by getting girls involved through an in-person Youth Think Tank (YTT); and by creating a new website (WEMADEIT.ca). Through interviews with five YTT participants, as well as an analysis of the content participants produced for the WEMADEIT website, this paper traces the journeys of a purposive sample of five teenage girls who have participated in the YTT. The researcher's autoethnographic insights as the daughter of a female engineer further enrich the paper's analysis and discussion. The findings suggest that exposure to engineering through the YTT generated greater interest in engineering and stronger self-efficacy in participants, opened up post-secondary conversation between participants and their parents and created positive outcome expectations for a career in engineering.

AWKNOWLEDGMENTS

To my incredible family – you may not have introduced me to engineering, but you've been one heck of a support system since. I love you all.

To Brian, who somehow managed to make me smile even after hours of being bogged-down in literature.

To the WEMADEIT team: Ruth, James, Lee, Lynsey, Kyla, and our 36 incredible YTT'ers. I am beyond blessed to have worked with all of you.

Finally, to Dr. Jean Mason, my supervisor, for providing me so much support throughout this process. It's been an absolute pleasure.

TABLE OF CONTENTS

LIST OF APPENDICES

INTRODUCTION

My mother is an engineer. She completed her degree in electrical engineering from Queen's University in 1980, one of only three women in her graduating class. She pushed through the "glass ceiling" into a senior management position within ten years. She loved her job. For reasons unbeknownst to me, my mother never told me what her job entailed; perhaps it was too difficult to explain, or maybe she assumed that I would not be interested. Each morning when she left for work, I imagined her boarding a train and sporting a traditional conductor's hat – a vision that still makes me laugh. This was the extent of my childhood understanding of engineering. Where this impression came from, I still cannot be sure. Regardless, I, the daughter of a female engineer, never even considered the possibility of pursuing a degree in engineering.

Recently, I began working with Ryerson University's Women in Engineering project on an initiative called *WEMADEIT* - an initiative that hopes to increase girls' exposure to authentic information about engineering in an effort to decrease the gender inequity that still exists in the field of engineering. A consortium of universities, made up of Ryerson University, the University of Western Ontario, the University of Waterloo and the Ontario University Institute of Technology have partnered with Hydro One to create the "Hydro One Women in Engineering University Consortium (WIE) (Ryerson University, 2014)." The goals of this four-year project are to improve:

- *Outreach*: "Expand current outreach activities undertaken at all participating consortium universities; increase female engagement with engineering as an area of study at the post-secondary level, and demonstrate the potential career paths with an engineering degree (Ryerson University, 2014)."
- *Support: "*Enhance the success of female engineering students through better support within the university, including networking events and mentoring (Ryerson University, 2014)."

- *Networks:* "Support female engineering graduates as they transition into the engineering profession through industrial networks and mentorship (Ryerson University, 2014)."

Within the WIE project, our research team at Ryerson University created "WEMADEIT", a brand designed to more effectively communicate the benefits of engineering to high school girls in a way that would appeal to them. As part of this project, 36 girls who were currently enrolled in high school were hired to participate in a Youth Think Tank (YTT) initiative in order to discover best practices for communicating the benefits of engineering to girls. These girls acted as researchers, interviewing their peers about communication best practices, as well as about their attitudes and assumptions about engineering. The participants also created web content for WEMADEIT.ca, a website aiming to teach girls about engineering and to encourage them to consider it as a career. This process also allowed our team to discover more about high school girls' reaction to engineering and to the WEMADEIT brand by analyzing the content produced by the YTT.

Social Cognitive Career Theory, based in Bandura's Social Cognitive Theory, suggests that self-efficacy, outcome expectations and personal goals are the three major contributors to career choice. Our team hoped that participation in the YTT would generate greater self-efficacy and interest towards engineering in participants, as well as positive outcome expectations and engineering-related goal setting. This paper traces the experiences of five participants through qualitative interviews, exploring whether participation in the YTT did in fact correlate with greater levels of self-efficacy and

interest, as well as engineering-related personal goals and positive outcome expectations for a career in engineering.

This paper is a tool of discovery, drawing on social science methods, humanities-style critical analysis and autoethnographic insights in order to theorize about the most effective elements of the WEMADEIT project. By interviewing five members of the YTT once as the project began and then a second time as the project concluded, I hoped to discover how the girls' participation in the WEMADEIT Youth Think Tank impacted their attitudes towards engineering, as well as to discover which elements of the YTT programming had the strongest positive impact on participants. Future research initiatives may wish to incorporate these elements into their studies, as well as elements of SCCT. Thus, the research question guiding my study is "how does participation in Ryerson's WEMADEIT Youth Think Tank change girls' attitudes towards engineering?"

THEORETICAL FRAMEWORK

Social Cognitive Career Theory (SCCT):

> *"Those who study career behavior [sic] have been re-discovering what career councilors typically accept as self-evident – that people help construct their own career outcomes; that their beliefs… play roles in this process; that we are not merely beneficiaries (or victims) of intrapsychic temperamental, or situational forces; and that behavior [sic] is often flexible and susceptible to change efforts" (Lent et al, 2002).*

SCCT is derived from Bandura's Social Cognitive Theory (1986), and suggests that there are three major foundational elements that contribute to career choice: self-efficacy, outcome expectations and personal goals. SCCT emphasizes that self-efficacy is a dynamic set of self-beliefs that are "acquired and impacted by four sources: "(1) personal performance accomplishments, (2) vicarious learning, (3) social persuasion, and (4) physiological and affective states" (Brown & Lent, 2004). Outcome expectations are "the imagined consequences of performing given behaviors [sic]" (Lent et al, p.262). SCCT cites Bandura as a major influence in defining goals as "the determination to engage in a particular activity or to effect a particular future outcome… by setting personal goals, people help to organize, guide and sustain their own behavior [sic]" (Lent et al, 263).

While SCCT posits that our vocational outcomes are shaped by the interactions between people and their environments, the theory also emphasizes the impact of personal agency. SCCT subscribes to Bandura's *triadic-reciprocal* model of causality, in which an

individual's personal attributes and overt behaviour interact with external environmental factors, allowing individuals to become "both 'products and producers of their environment' with the potential for self-regulation" (Lent et al, 2002, p. 261).

Self-Efficacy:

While interests undoubtedly play a part in the career goals of adolescents (Betzworth & Fouad, 1997; Hansen, 1984), "it is largely through repeated activity practice, modeling, and feedback from important others that children and adolescents are able, gradually, to develop their skills, adopt personal performance standards" (p.265) and gain self-efficacy and outcome expectations. While the SCCT concludes that basic abilities and personality do have genetic linkages, Lent et al. (2002) suggest that without exposure to a certain area of study, an adolescent will not gain interest or self-efficacy in that area, leading to negative outcome expectations and a lack of active goal setting in this field. According to a study by Bandura et al (2001): "Children's perceived efficacy rather than their actual academic achievement is the key determinant of their perceived occupational self-efficacy and preferred choice of worklife" (p. 187), suggesting that exposure and strong self-efficacy are two integral components in career choice. SCCT notes that changes in interests can occur at any point in life, but emphasizes that childhood and adolescence are the most effective times to develop career interests. SCCT also suggests that ability does not influence interest directly, but instead informs self-efficacy; positive ability creates strong self-efficacy, which creates positive outcome expectations and interest.

According to Eccles (1994), authority figures tend to treat girls and boys differently on the basis of culturally shared expectations of gender. This belief echoes the work of Bandura (1986), who suggests that barriers imposed on children based on their gender are often internalized, impacting their behaviour. These beliefs contribute to what Bourdieu (1989) terms as *habitus*: "the mental structures through which… [we] apprehend the social world," (p.18) in which deeply ingrained, culturally-formed assumptions have a subconscious impact on our actions, which we often assume to be natural. Doucet (2009) agrees, suggesting that habitus is gendered; though girls may protest, they are naturally pulled towards gender stereotypes that have been culturally reinforced. Though a girl may have interest in STEM (Science, Technology, Engineering and Math), the SCCT holds that they "will be more likely to have to compromise their interests in making career choices if they perceive that their environment is not supportive of their choice or if they perceive significant barriers to entering and prospering in careers that most interest them" (Lent et al, p. 976).

According to Bandura (1986), what people can accomplish is impacted by how they interpret and apply their abilities. Self-efficacy – or "how effectively people deploy their talents (Lent et al, p.278)" – can help to explain why two individuals with the same capability can produce measurably diverse results. For example, girls tend to exhibit lower levels of self-efficacy in STEM classes than boys (Halpern et al, 2007, p.16; Jagacinski, 2013). Many researchers chalk this up to "Stereotype Threat," which is defined as "a situational predicament in which individuals are at risk, by dint of their actions or behaviors, of confirming negative stereotypes about their group... Ironically,

this fear of stereotype confirmation can hijack the cognitive systems required for optimal performance and result in low test performance (Inzlicht & Schmader, 2011, p.6)." Likewise, "The power of stereotypes may help explain the puzzle of girls' strong classroom performance and relatively weaker performance on high-stakes tests (AAUW, 2010, p.5)," when compared to the performance of boys. For example, Huguet and Régner (2008) conducted a study in which girls between the ages of 11 and 13 were asked to recall details of a complex figure. They found that girls recalled fewer details when they thought it was a test of geometry, rather than memory or drawing, as well as when they were aware that there was a historical gender difference in scores (p. 556).

Lent et al. (2002) suggest that "self-efficacy plays an especially important role in determining how people employ their activites" (p.279). According to Bandura (1986), the most effective level of self-efficacy is belieiving one is moderately more able than their real ability level. This optimistic approach allows people to face challenges that help to cultivate greater skill. A major goal of WEMADEIT's Youth Think Tank (YTT) is to increase participants' self-efficacy in engineering, hoping it will lead to greater interest, positive outcome expectations and engineering-related goal setting. This paper will explore whether participation in the YTT correlates with an increase in these three SCCT elements: self-efficacy, outcome expectations and goal setting.

LITERATURE REVIEW

The Gender Gap in Engineering:

Many scholars have suggested that gender gaps within Science, Technology, Engineering and Math (STEM) fields in North American are lessening. However, these increasing numbers seem to apply only in certain STEM fields, such as biology, but not in others – least of all, engineering (Heilbronner, 2013, p. 39). In the United States, women received more than 57% of Bachelor's Degrees, yet less than 20% of Bachelor's degrees in engineering were awarded to women (The National Academies Press, 2010, p 49). Further, while women represent half of the American workforce, they only represent 24% of the STEM workforce. Worse still, between 2000 and 2009, women made up less than 14% of the engineering workforce (U.S. Department of Commerce, 2011). According to *Generation STEM*, a report by the Girl Scout Research Institute:

> "Due to technological advances, STEM jobs in the United States in the past ten years have grown at three times the pace of non-STEM jobs, and are projected to continue growing at this pace through the next decade. STEM jobs require technical expertise, specialized training, or higher education, making the typical job seeker in the United States under-qualified for a job in a STEM field. As a result, there are not enough qualified job candidates in the United States to fill all of these projected positions, even during this time of high unemployment (p. 4)."

Encouraging girls to pursue STEM fields benefits companies who desperately require additional talented STEM workers. At a time of heightened unemployment figures, it also nudges girls with an aptitude for these subjects towards a career path that promises more stability than most. Put simply, it presents a win/win situation.

According to Foor, Walden & Trytten (2007): "The processes of becoming an engineer, as well as the being and doing of engineering, have a gendered, raced, and classed recent

history: male, white, and privileged." This background has led to the stereotyping of engineering as a "male" profession that may be holding girls back from applying to post-secondary engineering programs. According to Knight & Cunningham (2004), when asked to draw an engineer, the majority of students – both male and female – were more likely to draw a man. Interestingly, Knight & Cunningham note that this disparity occurred even after the participating students had been working with two undergraduate female engineering students for months. These perceptions of engineering are important "since perceptions of careers are closely linked to whether students feel they can enter into those careers (Knight & Cunningham, p. 7)".

Despite stereotypes, Spelke & Grace (2006) conclude that there appears to be little dispute that, globally, male and female students show similar mathematical aptitude (Spelke & Grace, 2006; Hyde et al, 1990; Tartre & Fenema, 1995; Kimball, 1989). Though individuals do show predisposed talent in STEM subjects, there are few genetic differences between male and female ability in STEM (Spelke & Grace, 2006, p. 726). According to the Girl Scout Research Institute, "Studies show that girls lose interest in math and science during middle school (2012, p.2)," suggesting that this is where the STEM gender divide begins. While girls consistently earn higher GPAs in high school STEM classes, they are more likely to give up when the material is difficult (Girl Scout Research Institute, 2012, p. 6), suggesting lower levels of self-efficacy. Marra et al (2009) also conclude that female undergraduate engineering students with high levels of self-efficacy are more likely to complete their degree, suggesting that self-efficacy is crucial to success in STEM fields.

According to a mixed-method qualitative and quantitative study conducted by the Girl Scout Research Institute, even after classifying themselves as being "disinterested" in engineering, many girls express interest in engineering-related traits and activities. The study suggests that there is active female interest in STEM - noting that 74% of girls 14-17 reported themselves as being interested in STEM – but reports that engineering was the least popular subject within the STEM fields. This study consisted of a national diversified sample of 852 girls between the ages of 14-17. The respondents were then split into equal groups containing girls who identified themselves as interested and disinterested in STEM (p. 31). Within groups identifying as "interested" and "disinterested," the study then asked the subjects to agree or disagree with questions that revealed interest in STEM-related activities, including: "I like to understand how things work," "I like puzzles and solving problems," and "I like to understand how things are built (p. 9)." While girls who reported liking STEM agreed with questions 74.8% (mean) of the time, the mean of the 9 questions answered by girls who reported "disinterest" in STEM subjects was 53.8% (p. 9). Of those classifying themselves as disinterested in engineering, 70% claimed to, "like puzzles and solving problems (p. 9)" – a trait associated with engineering – despite the fact that they labeled themselves as uninterested in engineering. Even when girls choose not to align their identity with the "engineer" label, many girls who claim disinterest actually report interest in specific elements involved in engineering; these results suggest that the girls' perception of engineering is inaccurate.

In the same study, only 3% of girls who identified themselves as having no interest in STEM said they were interested in engineering - the lowest reported interest level within the STEM area (Girl Scout Research Institute, 2012, p. 9), providing stronger evidence that engineering has a particular problem with image. This idea is reflected by the findings in *Generation STEM*:

> "We find that many girls and educators don't know what engineering is or the reality of making this a career choice. I find it especially interesting that almost no girls (3%) who identify as not interested in STEM would choose engineering. It shows me that beyond other challenges, engineering has an image problem that needs to be changed (Girl Scout Research Institute, 17)."

This research suggests that girls may indeed be interested in engineering – they simply may not know it: "Interest among girls is there, it just needs to be primed… Girls may identify more with the process of becoming an engineer than with the idea or label of being an engineer when they grow up" (Girl Scout Research Institute, 2012, p. 25).

According to Nosek & Banaji (2002), "Associating the self with female and math with male made it difficult for women, even women who had selected math-intensive majors, to associate math with the self." These findings reveal that implicit stereotypes a girl holds about the relationship between math and gender, as well her feelings of affiliation towards her own gender, correlates with her attitude toward STEM. For example, if a girl feels that boys are innately better at STEM subjects, and she strongly associates with femininity, she will usually show a stronger dislike for STEM subjects. Nosek & Banaji also suggest that, "implicit attitudes toward math do not sit in isolation. Attitudes, beliefs, and identity form a rich network of thoughts and feelings that frame one's orientation toward the domain" (p. 56). This idea is reflective of Pierre Bourdieu's iteration of the

habitus: "the mental structures through which… [we] apprehend the social world," (p.18) in which deeply ingrained, culturally-formed assumptions have a subconscious impact on our actions, which we often assume to be natural. This research emphasizes the importance of viewing girls' relationship with engineering as part of a complex sociocultural framework.

In sum, girls are likely to hold a subconscious bias against STEM due to stereotypes and sociocultural factors; however, the majority of girls also face little exposure to the engineering industry, suggesting that an increase in exposure may lead to changes in attitude towards engineering. While the majority of research suggests that girls have aptitude in STEM subjects that is equal to boys – certainly enough to enter the field of engineering – many girls lack the understanding of what an engineer really does. For instance, many girls identify with the activities an engineer performs, yet claim not to identify with the label of "engineer." Popular opinion suggests that girls have lesser aptitude in STEM subjects, making girls more prone to stereotype threat. By educating girls about the realities of engineering, exposing them to the inaccuracy of gender stereotypes, and working to increase their self-efficacy in engineering, girls may be more likely to perform better in STEM subjects. WEMADEIT views the relationship between girls and engineering as fraught with communication problems that may be alleviated in part by providing girls with greater positive exposure to engineering.

Public Perception of Engineering:

According to the National Academy of Engineering (NAE) (2008), hundreds of millions of dollars are spent yearly in the United States in an effort to change the public perception

of engineering. Nonetheless, K-12 teachers and students continue to have a limited understanding of engineering (Knight & Cunningham, 2004). Despite a general positive attitude toward engineering, the majority of people believe that "engineers are not as engaged with societal or community concerns as scientists or as likely to play a role in saving lives" (NAE, 2008). In order to combat this lack of public understanding, the NAE commenced *The Messaging Project*, which aimed to "encourage coordinated, consistent, effective communication about the engineering community to a variety of audiences, including school children, their parents, teachers and councilors, about the role, importance, and career potential of engineering" (NAE, 2008). Typically, messaging targeted towards youth aims to emphasize that engineering is challenging, exciting, hands-on and rewarding, and requires an aptitude for math and science (NAE, 2008). However, the qualitative interviews and focus groups conducted by NAE revealed that new messaging was needed in order to attract young people to the profession. They developed "an optimistic, inspirational statement [that] emphasizes connections between engineering and ideas and possibilities, rather than engineering as a math and science based method of solving problems" (2008). The NAE rebrand emphasized engineers as inherently creative, concerned for human welfare, and emotionally satisfied by their career, stating that:

> "No profession unleashed the spirit of innovation like engineering. From research to real-world applications, engineers constantly discover how to improve our lives by creating bold new solutions that connect science to life in unexpected, forward-thinking ways. Few professions turn so many ideas into so many realities. Few have such a direct and positive effect on people's everyday lives. We are counting on engineers and their imaginations to help us meet the needs of the 21st century" (NAE, 2008).

The NAE also found that while public perception of engineering was not necessarily negative, the public did have a poor understanding of what engineers do. There was also a strong sense that "engineering is 'not for everyone,' and perhaps especially not for girls". They also found that current messaging does not place enough emphasis on communication, teamwork and creativity as vital aspects of engineering.

The "Global Engineer"

According to Chan & Fishbein (2009), the general public tends to define engineering by a limited set of required skills – specifically math and science. Meanwhile, when asked what elements interest them in a career, girls cite a desire to help people, to engage in teamwork, to make the world a better place, and to engage in creativity (Heilbronner, 2013; Girl Scout Research Institute, 2012). Because most teens openly admit that they are not familiar with the specifics of a job in engineering (Intel, 2011), it is possible that this limited understanding of engineering may be robbing girls of the ability to connect a career in engineering with their reported ideal career elements. Therefore, girls need to be exposed to the realities of a career in engineering in order to show them that these elements they hope to achieve in a career are in fact compatible with engineering.

Engineers Without Borders's (EWB) definition of the "Global Engineer" satisfies the ideal career attributes cited in the above paragraph. Chan & Fishbein (2009) describe the EWB's definition of the Global Engineer as having superior communication and interdisciplinary skills, a well-developed sense of social responsibility and ethics and an entrepreneurial mindset. Canadian Engineering Accreditation Board's (CEAB) current criteria was changed in 2008 to reflect these changes and now emphasizes teamwork,

communication skills, impact on the environment, ethics and lifelong learning (Engineers Canada, 2013). These changes echo recent academic literature, which advocates for a greater emphasis on humanitarianism in engineering education (Passino, 2009; Amadei & Sandekian, 2010; Schneider et al, 2008). WEMADEIT has the ability to introduce girls to this concept of the Global Engineer, in an effort to emphasize a view of engineering that may be more compatible with the career elements girls report as enticing.

Importance of Extracurricular Exposure to Engineering:

Heilbronner (2013) presents six key internal/external factors that have been reported as impeding on the likelihood of girls succeeding in STEM fields (ability, interest, self-efficacy, mentors, academic experience and workplace experience); however, she does not include one other important external aspect: extracurricular exposure. Existing scholarly work and research emphasizes the importance of exposing girls to engineering, suggesting that it leads to higher retention rates. According to Anderson & Gilbride (2007):

> "In order to increase the number of young women who choose to follow a career in engineering, it is important to ensure that they are as aware of opportunities in engineering as their male counterparts. Through the use of educational tools, such as mentoring programs, outreach projects, and career awareness conferences, it may be possible to increase the interest of young women in the engineering field." (p. 104)

The Extraordinary Women Engineers Project's (EWEP) research illustrates that high school girls have very little understanding of what engineers do. Girls tend to see engineers as people who love math and science, and too often echo the stereotype that engineers are nerdy or boring (EWEP, 2005). They suggest that a major reason for the lack of women in engineering is that girls and "the people who influence them—teachers,

school counselors, parents, peers, and the media—do not understand what a career in engineering looks like and therefore don't consider it as a career option (p.2)."

Zywno et al. (2013) assessed Ryerson University's "Discover Engineering" summer camp, suggesting that: "The objectives of the project are to educate young women about the challenges and rewards of engineering, and to motivate them to choose engineering as a career option (p. 364)." According to follow-up surveys, approximately 400 of the 720 Discover Engineering participants continued on to study engineering. Sinkele, C. N., & Mupinga, D. M. (2011) echo these findings, suggesting that effective exposure can be provided by parents, schools, mentors, job-shadowing experiences, class projects, and summer camps. Ryerson certainly isn't the only institution working to expose girls to engineering; a quick Google search will reveal the stunning number of programs dedicated to introducing engineering to girls. Some programs of particular note are EngineerGirl.org (for Middle School girls) and EngineerYourLife.org, created by the National Academy of Engineering in the United States, complete with modern branding and up-to-date information. Canada is also filled with Engineering-related programs targeted at girls, including the Alberta Women's Science Network (AWSN, 2014), WISEathlantic (Women in Science and Engineering, 2014) and the Ontario Network of Women in Engineering (ONWiE, 2014). There are also inventive programs, like EnGenious.ca, that use online interactive platforms to help girls develop skills that are required in engineering. Clearly, outreach programs designed to make the engineering profession more gender inclusive are increasing throughout North America.

Intel recently conducted a survey of 1008 teenagers between the ages of 13 and 18 to assess their understanding of and interest in engineering; a total of 597 of these students were female. Out of all survey respondents, 28% stated that they were considering pursuing a career in engineering - 37% of males and 18% of females (Intel, 2011). According to this study, once teens were exposed to and considering a career in engineering, they were more likely to identify engineering as: "gratifying," "cool" and "collaborative" (Intel, 2011). The study suggests that teenagers perceive engineers as making a good salary, having job security and having an impact on the world. This being said, the results of the survey suggest that familiarity with engineering is a weak link:

> "Almost one-third of teens do not know of potential job opportunities in engineering and 13 percent do not think that majoring in engineering in college will lead to any more job opportunities than any other major… Twenty percent of teens have no idea about engineering's impact on the world." (Intel, 2011)

In surveying a group of teens who were not currently considering engineering as a career, an encouraging 44% of respondents suggested that greater exposure to engineering or a better understanding of what engineers do would make them reconsider a career in engineering (Intel, 2011). After being exposed to information on engineering provided by Intel, there was a 17% increase in girls stating that they would consider a career in engineering; within the 13-15 age group, an even more encouraging 29% of girls stated that the information resulted in their reconsideration of a career in engineering.

This research suggests that greater exposure through extracurricular activities may be an effective way to get girls more interested in engineering.

IMPORTANCE OF THIS RESEARCH

When provided with the statement: "I know a lot about my career options in STEM," only 54% of girls interested in STEM agreed, while a dismal 31% of girls with low interest in STEM agreed (Girl Scout Research Institute, 2012, p.13). While answers like this seem discouraging, it is important to note that most girls who reported interest in STEM also reported greater exposure to STEM fields than girls who claimed disinterest in STEM. "Exposure was also higher in terms of experience in STEM activities. STEM girls were more likely to have done hands-on science activities when they were younger (51% versus 37% of non-STEM girls); visited science/tech museums (66% vs. 55% non-STEM); and engaged in an extracurricular STEM activity (36% vs. 13% non-STEM) (Girl Scout Research Institute, 2013, p.13)." These findings suggest that one of the most significant problems we currently face in getting girls interested in engineering is lack of exposure. According to Social Cognitive Career Theory, this lack of exposure will likely contribute to lessened interest in engineering, self-efficacy and outcome expectations, making girls less likely to pursue a career in engineering. Therefore, it seems clear that actively exposing girls to engineering and increasing their self-efficacy needs to become a priority; this is the objective of the WEMADEIT Youth Think Tank initiative.

This paper traces the journeys of five high school girls who participated in WEMADEIT's Youth Think Tank, while exploring the impact of this extracurricular form of engineering exposure. This paper will not attempt to generalize to all high school girls. It will instead act as a case study; future initiatives may wish to incorporate elements of this study into their own research.

METHOD

As the daughter of a female engineer and a member of the WEMADEIT team, I have inescapable personal involvement with this topic; therefore, in addition to drawing on social science methods and humanities-style critical analysis, my analysis includes minor autoethnographic elements, intertwining my own experiences and insights with the insights of my interviewees.

Framed as a modified case study, my research will consider the effects of participation in Ryerson's Youth Think Tank on a purposive sample of five high school girls. After receiving approval from the REB (see Appendix 3.0), I engaged five participants in a series of two interviews each, providing the basis for a critical analysis of their experiences with the YTT. The interview questions are located in Appendices 1 and 2. These interviews were conducted by phone in order to eliminate the need for the teen participants to travel around the city. This method also allowed the girls to be interviewed in a physical space of their choice, one in which they felt comfortable.

In my first round of interviews, I spoke directly to these five participants in order to discover if, when and how these girls were exposed to engineering, searching for patterns in their understanding of engineering, elements of engineering that appealed to them, and the nature of their interest in engineering. I analyzed the resulting data in order to draw out emergent themes. The second set of interviews, which took place after the completion of the YTT, consisted of questions that explored its impact on participants. Throughout the paper, these five girls are referred to using pseudonyms to protect their privacy.

In order to provide a further layer of reference for analyzing the interview data, I have also analyzed the WEMADEIT website (www.wemadeit.ca), using this data to enrich the data collected from the two sets of interviews. Because the entire website was created using content produced by the YTT girls themselves, the website as a whole illuminates the overall interests and sentiments of the participating girls. The element of the website that proved to be most pertinent was the "WeTHINK" section, which provided direct quotes from participating YTT girls on a variety of issues. As a general rule, the data collected from the website proved to be a useful way in which to compare and contrast the data collected through the interview process.

It is important to note that this paper is intended to be exploratory, not conclusive. The objective is analysis of a particular case, not generalization; however, it may be possible to view this research as a pilot study with the potential to adapt to a larger scale project. The collected data was analyzed using elements of exploratory thematic analysis, allowing for a process that was "less structured, more flexible, and inductive" (Guest et al., 2012, p. 6). This process broadly included: familiarizing myself with the gathered data; searching for emergent themes and patterns; and considering these themes and patterns within the above-described theoretical context. Specific codes and analytic categories were not predetermined, but were rather shaped by the compiled data. The flexibility of this method allowed for greater researcher interpretation, which I believe helped me to capture the nuances of the gathered interview data.

The Youth Think Tank Structure:

The YTT consisted of 36 girls between the ages 14-17, hailing from across the Greater Toronto Area. These girls comprised a range of backgrounds and experiences, as well as varied levels of prior exposure to engineering. They were required to attend a training session, in which they were taught the basics of qualitative research and practical interview skills. Each member of the YTT signed a contract agreeing to work for 2.5 hours per week over 10 weeks, receiving a minimum wage stipend for her efforts. Upon their first Youth Think Tank meeting, the girls were asked to place themselves in one of four groups according to their interests:

1) Lightning: How do girls' feelings about femininity impact decisions they make about their future?
2) Gears: How do girls communicate, on and offline?
3) Cubes: How do images affect the way girls perceive issues create meaning?
4) Droplets: What do girls know about engineering and what do they want for their future?

As opposed to creating website content that we hoped would appeal to young people, we asked young people themselves to create content for the site in which their peers would be interested. In order to create this content, each week the YTT members were asked to submit three assignments: a survey, two interviews and a "Co-Lab." Each group (Lightning, Gears, Cubes and Droplets) was allocated a variation of these aforementioned assignments that aimed to answer their group's target question. The surveys were answered by the YTT participants themselves and designed to provide us with data on their thoughts, ideas and behaviours. In order to complete the two weekly interviews, the YTT participants were asked to interview a variety of demographics – teen boys, parents, teachers and other teen girls – on issues pertaining to their group's overarching question. Each girl completed two interviews over ten weeks, resulting in 720 total interviews.

Finally, the girls were tasked with a Co-Lab - a creative weekly assignment that asked girls to create web content for WEMADEIT.ca. Co-lab assignments included: reviewing engineering-related Ted Talks, designing "Vision Boards" containing their dream futures, and creating internet memes relating to engineering. Elements of these weekly assignments were then used as content for WEMADEIT.ca. For a visual screen capture of WEMADEIT.ca, see Appendix 4.0.

Whilst the YTT program was in progress, the website was being created by the designated web creator. In Week 10 of the YTT curriculum, the girls were asked to give personal reviews and feedback on the in-progress website, helping us to assess whether the website looked the way *they* – our target audience – wanted it to. They were also asked to each submit two interviews - with a parent or teacher, and with a friend. During these interviews, they asked predetermined questions that were designed to gather stakeholder opinions on the in-progress website. The data gathered resulted in changes made to the final website.

Sampling:

In order to find interviewees, I attended the YTT's "Kick-off" meeting on March 22nd, 2014, where I introduced myself as a Master of Professional Communication graduate student at Ryerson who was researching how the current methods of communicating about engineering to high school girls might account for the low number of high school girls applying to post-secondary engineering programs. I explained that my hope was that the girls' interest in the Youth Think Tank (YTT) project would translate into an interest in volunteering for my study. I then provided the 36 girls with post-it notes to record their

email addresses for me. They were informed that if they chose to provide their email address, I would be emailing them with further information on participation in my study.

Due to my active role with the WEMADEIT project, I stressed that the interview was in no way related to YTT and that they were under no obligation to participate. I then left the room in order to give the girls space to choose whether or not to participate. The girls then placed their post-it notes in a folder. Once home, I emailed all volunteers, providing further information on the study, as well as a consent form that their parent/guardian was required to sign. For efficiency's sake, the parents were given the option of printing, signing and scanning back the consent form to me or alternatively emailing me with a predetermined message to provide their consent. After I received permission from the girls and their parents, I placed all names of possible participants back into the folder. I then randomly picked five post-it notes from the folder, followed by two other "back-ups" in case the study retention dropped. The five study participants were then emailed in order to organize a phone interview time.

Data Collection:

Each participant took part in two interviews – one in late March/early April while the WEMADEIT project was in its early stages, and another after the project was completed in late May. Both interviews took between 20 -30 minutes to complete. The interview questions (Appendices 1 and 2) were predetermined in order to guide the sessions; however, I chose to digress from the preset questions at times in order to allow participants to expand on certain concepts. The use of interviews as a data collection

method allowed me, as a researcher, to delve deeper into elements of the WEMADEIT experience that the participants were interested in, or that they felt had a particularly strong impact on them.

Analysis Techniques:

Following accepted practice for a qualitative-style study, "the data collection process is less structured, more flexible, and inductive (Guest et al., 2012, p. 6)." The collected data was analyzed using exploratory thematic analysis, meaning that specific codes and analytic categories were not predetermined – they were shaped by the gathered data. According to Guest et al. (2012):

> Thematic analyses… require more involvement and interpretation from the researcher. Thematic analyses move beyond counting explicit words or phrases and focus on identifying and describing both implicit and explicit ideas within the data, that is, themes (p. 10).

This method, and its allowance for researcher interpretation, helped me to more effectively capture the nuances of the interview data. In order to complete my thematic analysis, I familiarized myself with the data, generated initial patterns based on the collected data, searched for themes among these patterns (Braun V. & Clarke V. 2006). I analyzed the data using these 'found' themes and patterns to assess what impact participation in the YTT had on the five participating girls.

FINDINGS AND DISCUSSION

Girls Lack Exposure to Engineering

Correlating with the findings of Intel's 2011 study, all five girls who were interviewed revealed that they had applied for the YTT with only a vague understanding of engineering. Four out of five interviewees considered themselves to be good at math and science, scoring grades between 85% and 98%. This is not surprising, considering that the majority of Youth Think Tank participants found out about the initiative through their math and science teachers. What is surprising was that WEMADEIT attracted the interest of girls who did not consider themselves good at science or math. According to interviewees, the fact that they were paid was enticing, but their major interest in joining the initiative was their indignation that there were so few women in engineering:

> *It sounded like a really interesting project. I like the idea of giving women and girls more options… all you see is males. It's a male, mechanical engineer that's always portrayed in the media.*

While one interviewee did apply for WEMADEIT based on her preexisting interest in pursuing an engineering degree, the other four interviewees were clear that they were not interested in engineering when they applied for the program. For most of them, curiosity was a driving factor – they knew little about engineering and thought that participating in the program would be a good way to learn more about engineering while making some extra pocket money.

All interviewees mentioned in their preliminary interviews that they knew that engineering was a male-dominated discipline. However, when specifically asked to "describe an engineer," the girls offered a variety of answers. Laura and Brittany

described a "smart" looking man while Meghan and Natalie described a young woman wearing a lab coat. Nicole had a different answer, replying: "*I feel like I don't really see a gender when I think of engineers – I can see them both."* Interestingly, Nicole's sister recently graduated from an engineering program. Although she credits her father's heavy influence on her decisions, Nicole instantly made the connection between her sister's career path and her ability to picture a female engineer:

> *My biggest influence is definitely my dad himself. With my sister, she was partly an influence because I saw that she was studying engineering - that she was capable. That reassured me, showed me that I can do it.*

Nicole makes the connection that exposure to a female engineer not only made her capable of picturing both male and female engineers, but also provided her with a stronger sense of self-efficacy.

Laura and Brittany, the two participants who described a male engineer, also had stronger, more nuanced understandings of engineering in comparison to Meghan and Natalie, who both admitted that they knew very little about engineering. Interestingly, both Laura and Brittany also have male family members in engineering, possibly accounting for their stronger understanding of engineering:

> *I don't know a lot about it, but from what I do know, it's applied science. They take knowledge of science and build things. They're very analytical. They try and find different ways of solving problems, as opposed to a straightforward one. - Brittany*

I think an engineer designs and builds things, based on which faculty they're in. Chemical engineering, civil engineering, etc… depending on their strain, they'll solve problems and design things based on their education. - Laura

Just like Nicole, Laura and Brittany seem to have gained some exposure to engineering through their families, leading to a stronger understanding of engineering. Meghan and Natalie, who both described the young female engineers in lab coats, were both girls who confessed that they knew little about engineering. Neither of these girls had family members in engineering:

Engineers improve the world, for entertainment or anything. They construct things… figure out ways to make life easier. It's very math and science based. - Meghan

I don't think there's one thing an engineer does – but when I think of engineering I think of creating or discovering things. Like, if you were a mechanical engineer, you would be discovering how to fix vehicles. - Natalie

Though it may seem intuitive, these preliminary results suggest that the greater the levels of exposure to engineering, the more nuanced the girls' understanding of engineering was. This being said, exposure has an impact on self-efficacy in both positive and negative ways; the results suggest that girls picture that which they have experience with, meaning that girls who are exposed to certain male-dominated sections of the engineering industry may be more reliant on stereotypes. Nicole was exposed to both male and female

engineers, and therefore associates engineering with either gender. While Laura and Brittany, who have male relatives in engineering, have a more nuanced understanding of engineering, they find it more difficult to picture a female engineer because they are less likely to do so without direct exposure to a female engineer. Meghan and Natalie, with no prior exposure to engineering role models, both pictured a girl in a lab coat. This may suggest that without knowledge of the male-dominated engineering industry, they are able to picture a female. While this hypothesis requires further research, these results support the conclusion of both Anderson & Gilbride (2003) and Hoh (2009) that exposure to female role models in engineering increases girls' self-efficacy.

All five interviewees insisted throughout their interviews that not only they, but all high school students, lack exposure to engineering. They also explained how this is detrimental to both they and their peers' interest in applying to engineering school:

> *I don't think girls – or anyone really - knows what engineering is or what they do… I guess they [teens] just don't know what it [engineering] is. Guys are more willing to just try it, throw themselves into it. Girls want to know exactly what they're doing. – Brittany*

During her follow-up interview, Brittany – echoing Natalie, Nicole, Meghan and Laura- stressed how little her friends knew about engineering, and decided that their interest would be greater if they simply knew more about the subject:

> *I think that yeah, if girls knew what I know about engineering, they might be more interested. All of my friends are… really into math and science. I think if they knew more, they'd consider it. - Brittany*

Nicole provided an interesting hypothesis as to the reasoning behind the gender gap in engineering, also suggesting that the main issue is lack of exposure:

> *I'm not sure why boys are more interested than girls… I think maybe girls think that engineering jobs or technological jobs aren't as feminine or girly. But at the same time, I feel like the root of it is that no one is clear about the actual areas of engineering. It might also be the boys who go into engineering might be more interested in the stereotypical image of engineering – the software, the buildings.*

According to SCCT: "self-efficacy and outcome expectations regarding activity involvement exert an important, direct effect on the formation of career interests… people form enduring interest in an activity when they view themselves as competent at it and when they anticipate that performing it will produce valued outcomes" (Lent et al, p. 265). However, without being educated about and exposed to these activities, self-efficacy and realistic outcome expectations are not possible. Four interviewees claimed that they entered the YTT without a solid understanding of engineering – even with strong levels of self-efficacy in math and science; without an understanding of engineering and its possible outcome expectations, the girls are unlikely to develop an interest in engineering.

Personal Goals

While the majority of interviewees emphasized that they were still unsure about the path they wished to pursue in university, they were very open to discussing their ideal futures. The "dream" careers of the girls were in a wide variety of fields: medicine, education,

coaching, criminal psychology and engineering. Interestingly, though their dream careers were varied, they consistently cited the same few reasons for wanting to pursue a career: *interest*, *impact* and *fun*. Their descriptions of why these careers appealed to them revealed how important it was to them that their work could "make a difference." Nicole, who is applying to post-secondary engineering programs, noted the importance of seeing the impact of her work:

> *I think the part of engineering that I'm interested in is that you're solving problems. You're looking at something that can be improved, or some way you can make the world better…. Designing something, or surveying people – at the end of it you need to see what impact your solution might have.*

Natalie, who passionately explained her goal of working with Autistic children, discussed the importance of helping other people. Without specifically mentioning the word "impact," she made it clear that she wanted her work to be meaningful:

> *I think my dream job would be working with kids – I really enjoy working with children. I'm thinking of going into childcare with special needs children. I think it would be very rewarding. I like the idea of helping other people, and I think that a lot of people don't really understand Autistic kids – the idea of helping people better understand how they operate… I think I would enjoy that aspect of it.*

The other elements that appeared to be important to the interviewees were interest and fun. Correlating with the SCCT, the interviewees appeared to be drawn to careers that correlate with the skills and interests they currently possess. For example – Meghan mentioned her skill in athletics, as well as her passion for living an active lifestyle. She

therefore deduced that her ideal career might be in coaching: "*I don't want to sit at a desk and work – that kind of job. I want to be out there and active, because I find that more fun."*

Based on the results of the interviews, confidence about career direction appears to grow after discussing options with parents, teachers, or both:

> *I've talked to my parents about engineering. We talked about the different options and stuff around engineering. They want me to be very educated about the different paths I could go down. We talk about it a lot and they'll research different paths and we'll weigh the pros and cons together. - Brittany*

This finding supports the SCCT's position that "familial and other social influences can have an important bearing on career choice" (Lent et al, p.276). Other factors that were cited by the girls as factors that encouraged them to pursue career paths were: the media ("*My dream job is based off of a T.V. show, but I kind of want to be a spy. Maybe work for CSIS."),* high school career classes, and guidance councilors *("During this careers presentation we had, I saw a presentation on criminal psychology, and that was cool.").* These results also support the theory that exposure leads to greater interest.

An Education in Outcome Expectations

All five interviewees specifically credited their participation in the YTT with a newfound respect for engineers and a greater understanding of the full scope of possibilities that a degree in engineering provides. Further, the level of nuance in the girls' follow-up

interviews suggested how much their understanding of engineering had changed throughout the process.

During their first set of interviews, I asked the girls whether they thought they had a strong understanding of what an engineer does. I prefaced this question by explaining how long it took me, as the daughter of an engineer, to produce a solid definition of engineering, emphasizing that they should not be ashamed of their knowledge level. In response, four interviewees admitted that they knew very little about engineering prior to applying to the YTT – including Laura and Brittany, who both have family members in engineering. Their understandings were valid, but vague. It is also important to note that the majority of girls also confided that they "Googled" or "Wikipedia-ed" engineering before starting the project, meaning that they may have had an even more limited knowledge prior to hearing about the WEMADEIT project:

> *I came into WEMADEIT without knowing much about engineering – I did a Google search before WEMADEIT… I knew it had to do with math and science, but not really anything about engineering specifically. - Laura*

During their follow-up interviews, I prompted the girls to disclose any new information they had about engineering that they did not possess prior to participating in the YTT. Without hesitation, all five participants mentioned that prior to participating in the Youth Think Tank, they had no idea how many different strands of engineering there were. The girls were unanimously shocked to learn how many career paths were opened up after completing an engineering degree:

Thinking back, I really didn't know that much about engineering before WEMADEIT. I knew it was very math and science based, and that you have to think analytically and problem solve. But I didn't know how many strands there were and how many careers can come out of it. - Brittany

The girls were also asked during their original interviews to "provide a physical description of an engineer", as well as to "describe what an engineer does as a career". While Nicole immediately raised concerns about describing "an engineer" – a term I purposely left vague to gauge their reactions – the four other participants did describe a single engineer. During their follow-up interview, I asked the girls to answer the same question – interestingly, this time all five girls raised concerns about describing a singular engineer:

My view of engineers has changed slightly since the beginning of the project. I don't have as black and white a picture now. When I think of all the different types of engineers, I can't picture just one image… they do so many different things. - Natalie

This change in perception suggests that through the YTT process, the girls discovered how varied engineers can be, making it far for difficult to pin engineering down to a single definition. While this may make it more difficult for the girls to imagine a single outcome expectation, it also provided them with an understanding of how many options are opened up after completing a degree in engineering. According to a quote listed in the WeTHINK section of WEMADEIT.ca, girls may prefer these options, as the idea of being pigeonholed into a career is stressful:

High school students, boys and girls, are stressed out and confused about their futures. None of us know for sure what we want to do for a career, which isn't surprising, since we're only aged 13-18!

Multiple interviewees specifically noted that the importance of interviewing engineering graduates, as it gave them real-world examples of successful engineering graduates in non-engineering related positions:

There are so many kinds of engineers that I didn't know existed. One of the engineers I interviewed said she went to her reunion and almost no one was actually an engineer anymore. That's kind of cool because you can do anything with it [an engineering degree], which I didn't know. - Brittany

Nicole, who is heading for engineering school, noted the confidence that this knowledge provided her:

After talking to real engineers I have a better understanding of how many job opportunities there are out there. If I found one area of engineering not to my liking, I can use the skills I learn in engineering in other areas as well. I'm way more confident that once I graduate it's not like "oh I'm an engineer now, that's it." It made me feel a lot more relaxed that it'll give me that freedom.

For the girls, this was an important realization. Their shock that engineers could embark upon highly variable career paths revealed that teen girls might be under the impression that an engineering degree is limiting, rather than empowering. The realization that taking a degree in engineering did not necessarily mean that they were forced to continue on

into an engineering career may in fact detract from the stress high school girls reveal that they are under.

Once the girls discovered how many strands of engineering were available to them, they each began to reference specific areas of engineering, as opposed to simply using the general term "engineering". This supports the girls' claim that their knowledge of engineering underwent a significant increase:

> *Before I joined the YTT I used to think engineering was mainly just creating things that help other people – other than that, I didn't really know much about it. Now I know there are so many different branches of engineering. Say, environmental engineers – they help make things related to the environment. I now know that if you get a degree in engineering, it can help you with other careers too. – Meghan*

The excitement raised by the number of available areas of engineering suggests that future initiatives should emphasize the broad scope of engineering disciplines. One particularly meaningful quote came from Natalie, the interviewee who was originally the most clear about her definite lack of interest in engineering as a career:

> *I think everything about my mindset about engineering has changed. Now when I think about engineering, I think about all the different fields. I think that just about anybody, looking into just about any kind of work, should look into it [engineering], because there are so many forms of engineering to choose from.*

These results suggest two major outcomes that emerge from educating girls on the many types of engineering: (1) they feel less confined by taking a degree in engineering, and (2) they are able to search for an area of engineering that appeals to their interests.

Increasing Self-Efficacy and Interest through "The Global Engineer"

In light of the 2008 CEAB accreditation changes and the definition of the Global Engineering provided by EWB – and armed with the knowledge that girls cite interest in making an impact, working in teams and being creative – a major aim of the WEMADEIT project was to create a brand that could communicate the compelling elements of engineering to high school girls by emphasizing connections between engineering and the aforementioned attributes. It was therefore a thrilling moment when, without prompting, three of the girls emphasized the importance of creative thinking in engineering:

> *Another friend of mine, she has an artistic side, so she's always thought: 'oh, engineering and arts don't go together' – but a lot of the professional engineers I talked to combine both areas into their jobs now… She thought that engineering limits your thoughts and creativity – but in my mind, it's the other way around. Like, all the things that are around us were made by engineers – that's creativity to the max! - Nicole*

> *As an engineer, you need to like math and science, obviously, but also think creatively and solve problems. - Brittany*

> *They would be good at it [engineering] because they're creative and good problem solvers. They're good at math and science, which is really important because it's needed in all forms of engineering... but they're also all very innovative and creative, skills like that. - Meghan*

Emphasizing the need for creativity in engineering may appeal to a different set of university applicants, providing more diversity to the pool of applicants. Typically, engineering has been regarded as a profession that has focused on technology, but has avoided becoming intertwined with politics, ethics, or social issues (Tuerk & Lee, 2014). However, recent literature reveals that engineering professionals are increasingly emphasizing the importance of engineers becoming actively involved in environmental, social and ethical issues, stressing that engineers have a unique ability to solve complex issues that have arisen from our increasingly globalized world (Tuerk & Lee, 2014). Currently, engineering is being championed as challenging but rewarding, requiring strong skills in math and science (EWEP, 2005). However, when the WEMADEIT YTT girls were asked: "Girls should know _____ about Engineering," one of the answers given was:

> *That engineering is also about creativity and design (not just lots and lots of math and science which seems to perturb and scare some people).*

Based on the girls' positive reactions to the idea of engineering requiring creative minds, future research should look into whether depicting engineering as a highly creative career has a positive impact on girls' interest in engineering.

Based on previous research, we know that girls are interested in careers that will provide them with the following elements: enjoying their job, being in a good working environment, making a difference and having a good income and flexibility (EWEP, 2005). Based on the answers given during their preliminary interviews, the girls seem to view engineers as either working at desks or in a lab. While many engineers do in fact work in offices, they are far from limited to that working environment. Based on their follow-up interviews, it appears that all five girls have also reached this conclusion since their participation in the YTT. For some girls, researching impressive feats of engineering helped them to understand how interesting and interactive engineering can be:

> *I definitely thought engineers worked in the office way more than I do now. Mainly because after finding out about some of the very cool things engineers do, I'm thinking – how can you do all that in front of a desk? … I now consider engineering much more interactive… It takes more than one person, for example as an electrical engineer, to design a power grid. Before I pictured it more solitary, as people sitting at their desks. - Laura*

For other girls, talking to professional engineers provided them with tangible examples of engineers who work out in the field:

> *Some of the engineers I interviewed are actually out in the field – environmental engineers get to go out and see the world so that they can go and improve it, obviously! I met an engineer today who had to go into the CN Tower above the skywalk to test his stuff. That's definitely not sitting at a desk. - Meghan*

These results further support the theory that increased exposure to engineering, particularly exposure that emphasizes the variety of engineering careers, is correlated with increased interest in engineering.

While one interviewee, Nicole, seemed to have a solid understanding of how interesting engineering projects could be, the other four girls revealed in their follow-up interviews that engineering was far more interesting than they had originally believed:

> *I think engineering is a lot cooler than I originally thought. I think that's partly because of the Co-labs I did… they made me look into engineering news events and see some of the fantastic things that engineers are doing - and the not-as-cool ones that are important too* <laughs>. *It's given me a more in-depth understanding of engineering - Laura*

Based on the girls' shock and enthusiasm over how "cool" engineering projects could be, we can infer that they did not initially have a strong understanding of what engineers can create. This inference is supported by further direct quotes from the girls, which suggest that their friends are equally unaware of the interesting projects that engineers take part in:

> *Some cool engineering projects might motivate my friends to get more interested – make them think, yeah this is something I could do. - Brittany*

Exposing the YTT girls to interesting engineering projects appeared to increase interest in engineering, suggesting that future initiatives may wish to incorporate this element of YTT programming.

The Importance of Interviewing Engineering Professionals and Students

One element of the YTT that the girls consistently cited as being both enlightening and enjoyable was the interview process, in which they were asked to conduct interviews with their classmates and peers. Three participants noted that interviewing their peers gave them greater insight into how little their peers know about engineering:

> *I think I've learned a lot about engineering, as well as other people in my grade and university experiences… the interviews also taught me about my friends and peers' thoughts and opinions that I might never have known otherwise. - Laura*

> *I've really enjoyed my experience with the YTT. My favourite part has been the interviews – especially with my peers. I've loved learning about their opinions and ideas because they all vary so much, even from my own opinion. - Natalie*

While the girls made it clear that they enjoyed discovering more about their peers' thoughts and ideas about engineering, the majority of them were shocked by how little their peers knew about engineering:

> *I feel like one of the bigger parts of my discovery, I found out about during WEMADEIT interviews. I feel like most people don't know about all the different areas of engineering. The understanding is really limited. People usually think of software or of making buildings. - Nicole*

These results are not surprising when placed in the context of the existing literature, which suggests that most teens have a limited understanding of what engineers do

(Knight & Cunningham; EWEP; Intel; NAE; Chan & Fishbein; Girl Scout Research Institute).

One specific element of engineering that girls did seem to know about was how integral an aptitude in math and science is to pursuing engineering as a career, which supports EWEP's (2004) findings that "high school girls believe engineering is for people who love math and science" (p.3). While an aptitude in math and science is certainly required to complete an engineering degree, some of the girls I interviewed used the results of their interviews with professional engineers to combat the idea that engineering is predominantly math and science related:

> *Another thing I discovered during another interview was that girls say 'engineering is too hard,' even when she's good at math and science. People keep repeating that you have to be good at math and science, but a professional engineer I interviewed told me that her job is nothing like the educational experience. So that goes hand in hand with people not knowing what engineering is actually about. - Nicole*

These findings suggest that interviews with professional engineers may be a highly effective way to provide girls with a better understanding of engineering. They also support the findings of Anderson & Gilbride (2003) and Hoh (2009) in suggesting that successful female role models in engineering have a positive impact on girls' self-efficacy.

When asked about their experience with the YTT program, the girls all mentioned the interviews with professional engineers as being particularly enjoyable and informative. More than one interviewee mentioned being taken with how much the professional engineers enjoyed their jobs: *"I really liked interviewing the engineers, because it gave me a couple of different perspectives on engineering – plus they loved being engineers."* This enthusiasm for interviewing positive female role models reflects the findings of Betz & Sekaquaptewa (2012), who found that women perform better after being exposed to the success of other women. While girls can simply Google "female engineer," Brittany pointed out the difference in impact between the information found online and hearing about engineering directly from the mouth of a woman who has experienced it. She supplemented this statement by emphasizing the difference between WEMADEIT.ca and other engineering sites, noting that the WEMADEIT site might get girls to reconsider their disinterest in engineering. Nonetheless, her statement made it clear that talking directly with engineering students and professionals had the strongest impact on her:

> *Talking with engineers or engineering students would help my friends know more, as opposed to the general stuff that everyone knows or that you could find online. Some cool engineering projects might motivate my friends to get more interested – make them think, yeah this is something I could do... I think if a Careers teacher took girls around an engineering site that didn't appeal to them, they'd think it was boring and general. But if they were taken around WEMADEIT, the information is so interesting that it might actually get them to reconsider.*

Another benefit to having the YTT participants perform interviews was not only the knowledge they received, but also the confidence they gained by being placed in a position of authority:

> *With professional engineers, I chose to interview people through the phone [instead of by email] – and at first I was a little stressed about it, but it pushed me out of my comfort zone. It actually helped me grow through the experience. - Nicole*

While interviewing professional engineers gave participants a better understanding and more concrete information about the variety of engineering jobs available to engineering graduates, the girls also stressed how much they enjoyed learning about the hobbies and personal lives of these women. Based on the girls' interviews, it appears that these interviews helped them to see these professional women as well-rounded – "real" people. One interviewee was taken in by how many of her interviewees volunteered for causes they believed in while they worked or studied, including volunteering to help youth better understand engineering:

> *After talking to the interviewees, I found out that they… volunteered for different events. Now that I know a little bit more about groups, like Engineers Without Borders or Let's Talk Science, I know it's one way I can get involved. So it opened my eyes to getting involved in groups like that, plus getting involved with the engineering community. I can still participate in these things while I study or work. - Nicole*

Another benefit to participation in interviews with engineering students was the amount the girls learned about their university options. They reported having a greater understanding of clubs and activities that engineering students engage in outside of their classroom experience.

> *It [the YTT] also taught me more about university options that I might never have considered…. I don't know why I've never considered them… but some of the groups, like Engineers Without Borders and Ryerson Formula One, stuff like that about the universities. - Laura*

The girls also were shocked by how many options a degree in engineering provided. As mentioned previously, the interview process appeared to provide the girls with a better understanding of how an engineering degree opens doors for them, as opposed to limiting their choices.

> *They gave me different insights on different types of engineering. One of the questions was "where are they now" and they [interviewees] all worked for different companies. Some worked with big companies, some worked for small – it's cool to see how different their jobs are even with the same degree. - Brittany*

Based on the girls' higher level of confidence in their capabilities during their follow-up interviews, as well as their overall enthusiasm for interviewing female professional and student engineers, we can infer that providing girls with female role models in engineering may indeed increase self-efficacy and interest in engineering. Laura provided a strong statement that highlights the importance of providing female engineering role models:

Originally I only pictured engineers as males – and even though its still really male-oriented – I think that after being around female engineers through WEMADEIT, I can also picture a female engineer. – Laura

The Youth Think Tank: Opening Up Lines of Communication

One theme that appeared to run throughout the interviews with YTT participants was importance of family support. Laura, whose father and two uncles are engineers, felt that she had never really been versed in what an engineer does, despite her family connection to engineering:

I knew very little about engineering. I knew a bit based on my family - I knew it had something to do with building parts for systems, but I really didn't have a concrete definition or specifics… it sounded boring. I knew it had to do with math and science, which I like. I thought about engineering as civil engineering… roads and stuff. My uncles, they did something to do with steel. Steel, roads… something. Not too interesting. – Laura

During her follow-up interview, Laura reported that she was now engaging in discussions about engineering with her family.

This was a common theme for the girls in the YTT. Brittany, whose grandfather works as an engineer, revealed that her participation in the YTT had opened a channel of conversation between herself, her father and her grandfather. Brittany described herself as entering into the project with an interest in medicine and a limited understanding of and interest in engineering. However, she grew curious about engineering as the initiative

continued. In her first interview, Brittany described how her father started talking to her about engineering after she applied the Youth Think Tank:

> *I'm not entirely sure what I want to do as a career, so I'm going to look into parts of engineering… like biomedical, because I'm interested in the medical aspects. I want to know more about the pathways. Over the Easter break, my dad was looking into it for me and found genetic engineering – that sounds really cool.*

Brittany confessed that she had always been interested in the medical field, a passion that grew once she started learning about genetics. Her parents also knew this and responded by supporting her newfound interest. She not only described them as supportive of her interests, but noted that they took tangible steps to help her succeed:

> *I've talked to my parents about engineering. We talked about the different options and stuff around engineering. They want me to be very educated about the different paths I could go down. We talk about it a lot and they'll research different paths and we'll weigh the pros and cons.*

As the daughter of an engineer, I found these results particularly heartening. Parents may simply be unaware of the possibilities engineering holds for their daughters. Because I never engaged in a program like the YTT – or any STEM extracurricular activities for that matter – perhaps my mother interpreted this as lack of interest, when in reality it was simply a lack of exposure. By participating in the YTT, girls are showing their parents their active interest in learning more about engineering, therefore providing an obvious opening for parents to begin discussing engineering programs with their teens.

Conversations with friends and peers appear to be more complicated. After I asked Brittany whether she and her friends ever talk about engineering when they hang out, she responded: *"Um, not really. Engineering isn't really something we normally talk about."* This was a consistent response from the girls. It appears that regardless of the level of interest in engineering, career paths are not something that these high school girls regularly discuss. This being said, the three interviewees who described their friends as "good" at math and science were also the three girls who noted that they might continue conversing with their friends about engineering. These results are not surprising when viewed through the lens of Bourdieu's habitus, which suggests that the culture that surrounds us has a subconscious impact on our opinions and ideas (1989). If an individual spends time with a group of friends who are positive about math and science, this theory would suggest that engineering would be a more acceptable topic to bring up.

Though the majority of girls expressed that engineering was not going to be a frequent topic of casual conversation, the interviewees all noted that they planned to use their new knowledge of engineering to help friends who might be considering the field. Three out of five girls even agreed that they would recommend engineering to a friend who might not be considering engineering, but for whom they thought the career would be a good fit:

> *If I meet someone who's really good at math and science and seem passionate about those subjects, I would definitely encourage them to go into engineering. - Meghan*

I think in general, I tend to leave people's school choices up to them, but I might encourage them to look into engineering. Now that I've done this, I've learned a lot through this process and shared it with them, so it [talking to them about their career path] wouldn't be as awkward anymore. I think I would probably push some of my friends to do it [apply to an engineering degree]. One of my friends thinks she's not smart enough, but I was thinking "are you kidding me, you're one of the smartest people I know". So I'll encourage her. Definitely at least to check out WEMADEIT.ca. – Laura

I've talked to friends outside of the Youth Think Tank about engineering a little bit… one of my friends is actually considering engineering! – Natalie

Increased Knowledge, Interest and Self-Efficacy:

Due to reports of low self-efficacy girls exhibit when faced with STEM (Heilbronner, 2013), one of the major goals of WEMADEIT was to empower participants with knowledge and to increase their confidence that engineering was a viable career option. Encouragingly, participants all revealed that they felt more knowledgeable about engineering after completing the YTT process: *"Now I have way more to say because I actually know what engineering is and have things to say about it. I've learned about it from WEMADEIT" (Laura).*

All of the girls noted that their comfort level when discussing engineering, or topics related to engineering, had increased since the completion of the YTT process:

I don't talk to my friends that much more about engineering, but when we do talk about it I'm much more educated and can bring a lot more to the conversation. – Natalie

This suggests a change in outlook from EWEP's study in 2004, which concluded that: "They [girls] do not have an understanding of what engineering is. They do not show an interest in the field nor do they think it is 'for them'"(p.3). The girls' interviews certainly suggest that they have come out of the program with considerable interest in engineering:

In all honesty, one of the reasons I joined WEMADEIT was because I knew pretty well nothing about engineering. My idea about engineering was probably the same as most girls my age have. It's more of a man's field – building things, creating things… I had heard of engineering, but seldom and not very much… I think everything about my mindset about engineering has changed. Now… I think that just about anybody, looking into just about any kind of work, should look into engineering, because there are so many forms! There's likely a field that'll be interesting to you. - Natalie

Knowledge was not the only element the girls gained from the YTT; three out of five interviewees noted in their follow-up interviews that they were now considering engineering, suggesting increased self-efficacy. As the YTT began, the only girl considering a career in engineering was Nicole; however, by the follow-up interviews, both Brittany and Laura were also strongly considering applying to engineering programs:

WEMADEIT has definitely opened me up to the idea of taking engineering in university – it's made me consider it much more. Before it was like,

"yeah, I like math and science," but was considering doing other stuff like economics. But now I'm really considering it… I think I already would have taken math and science courses in high school no matter what, but… it's definitely opened the door to engineering a lot wider. Although I'm still not positive if engineering is what I want to do – I'm in grade nine, so there's still a lot of time and I don't know exactly what I want to do – engineering is on my list of careers that could be really interesting. - Laura

Before WEMADEIT I wanted to go to medical school and go into genetics. I still might want to go down that road, but now I'm looking into engineering and general science more so I can make the right decision. I'm thinking less about going into medical school and more about going into genetic engineering. You could get a 4 year degree in engineering and have a really great job instead of tons of time in med school. - Brittany

Natalie, who began the process by claiming to be "*not great*" at math and science, was emphatic that she was planning on follow her dream of working with children with special needs:

Honestly, I kind of have a set idea of what I want to do when I'm older, I have for the past three years. I found it really interesting hearing about engineering, but I already know what I want to do. – Natalie

Meghan, who was unsure of her career plans as she began working with the YTT, completed the program with a similar outlook:

I have no idea what I want to do in the future – I'm interested in so many different things that are so different from each other. I'm interested in sports and music and don't want to give up on either. But I do think engineering is such a cool and interesting job – you get to help other people, which is great. The YTT taught me that I like to talk to other people, so I want a social job. I don't want to sit at a desk. – Meghan

Though working in the YTT did not propel Meghan directly into an engineering undergraduate degree, the results were equally heartening. Meghan completed her term with the YTT possessing a greater understanding of what she wants out of a career. While the overall goal of WEMADEIT is to increase the number of girls applying to post-secondary engineering programs, it is important to emphasize that its secondary function is helping girls to find a career that they will truly enjoy.

In the exploration of whether the Youth Think Tank was an effective method of increasing enrollment in post-secondary engineering programs, it was encouraging to hear that one interviewee, Nicole, was offered a spot in the University of Toronto's Engineering Physics program. By her follow-up interview, she had officially accepted her offer:

This year I am going into engineering for my undergraduate education… I'm still not sure if I want to work as a professional engineer yet, but I feel that going into an engineering bachelors will give me the opportunity to keep my options open. – Nicole

The data gathered from the interviews suggest that by exposing the girls to engineering and providing them with an idea of possible outcome expectations, the girls completed the program with increased self-efficacy. This inference is supported by the fact that only one girl entered the YTT considering engineering as a post-secondary option, but four out of five left the YTT holding onto engineering as an option. This suggests that the girls now believe that they, both as individuals and as girls, can become engineers:

> *Personally, I think that girls have so much to bring to the table. I think it's important because we have a different way of looking into engineering than men do. – Natalie*

CONCLUSION

The collected data reveals that for the five interviewees, participation in the YTT generated more interest in engineering, greater self-efficacy and positive outcome expectations, providing the elements that SCCT prescribes as fundamental to career choices. This suggests that the YTT programming communicated engineering to teenage girls more effectively than the engineering messaging to which the girls were previously exposed. Future research may wish to explore and initiatives may wish recreate the elements of the YTT that were most successful in generating self-efficacy, positive outcome expectations and personal goal setting.

The majority of existing engineering messaging directed to students suggests that it is a good choice for those who want a challenge and who enjoy math and science; however, the YTT took a different route, echoing the definition of the Global Engineer, created by the EWB and supported by the current CEAB guidelines. YTT messaging emphasized the importance of engineers possessing strong creativity, teamwork and problem solving abilities. This messaging was conveyed to participants through research assignments in which the girls discovered the number of successful female engineers who possessed these qualities. This research was further reinforced by the girls' interviews with professional female engineers and engineering students, who echoed the importance of these traits. This exposure to new engineering messaging – that of the Global Engineer – appears to have generated greater interest in and knowledge of engineering for all five interviewees.

The five interviewees stressed the positive impact generated by interviewing professional engineers and students, emphasizing that this interaction with real engineers gave them a better understanding of what a career in engineering entails. All five girls were particularly excited by how many career options a degree in engineering could lead to; these results also suggest that high school-aged girls are wary of limiting themselves to a single career path. Exposing these girls to real engineers and engineering students gave them a better understanding of how engineering can satisfy their personal goals, resulting in positive outcome expectations.

The girls' confidence also appeared to increase after being exposed to female engineers. Originally, the participant who is related to a female engineer was the only interviewee to note that she could picture engineers as either male or female, specifying that both genders were equally capable. Once the project ended, however, the majority of girls stressed the importance of women in engineering, noting that women may bring different skills to their work than men. These results suggest that participation in the YTT, and specifically being exposed to female engineering role models, may have played a part in generating greater self-efficacy in participants.

The interviewees began the interview process by admitting that they knew little about engineering. By the completion of the YTT project, the girls were able to vocalize considerably more knowledge of engineering than they could during their first interview. While the girls originally described engineers as working at desks and in labs, often in isolation, the majority indicated in their follow-up interviews that engineering was far less boring than they had originally imagined. When asked about their "dream job," all

five participants stressed the importance of making an impact, being interested in their work and having fun. Four girls also emphasized the importance of working in a social space. By taking these goals into account, it is possible to shift messaging in order to connect engineering to the girls' personal goals, increasing the likelihood of them considering post-secondary engineering programs.

According to Social Cognitive Career Theory, the three major foundational elements that contribute to career choice are: self-efficacy, outcome expectations and personal goals. Bandura's Social Cognitive Theory (1986), on which SCCT draws, suggests that strong self-efficacy is integral, as it can have a positive impact on ability. The Youth Think Tank embodied these elements of SCCT and SCT inasmuch as it worked to increase participants' self-efficacy by providing female engineer role-models, by exposing them to the accomplishments of female engineers, and by involving them in the movement to increase the number of female engineers. By showing these girls their capability, as well emphasizing the impact they can have on the world around them, the YTT initiative appeared to increase these five participants' self-efficacy. This increase in turn appeared to generate greater interest, more positive outcome expectations for a career in engineering, and for the majority, engineering-related goal setting.

One unexpected, but wonderful, outcome of the YTT was its effectiveness in opening up lines of communication between participants and their parents and friends. Though the girls remained steadfast in their belief that engineering would never be a popular topic of conversation between friends, they all noted that participating in the YTT resulted in them updating their friends more frequently on interesting engineering projects they had

discovered through their work on WEMADEIT. Participants were also more likely to discuss engineering with their parents after joining the YTT; more importantly, participating in the YTT appeared to act as an icebreaker between participants and parents, allowing parents to discuss engineering as a potential career with their teenage daughters.

As the girls began their YTT journey, only one participant planned on applying to engineering programs in post-secondary school; however, as the program finished, two girls were considering post-secondary engineering, and another had accepted her offer to an engineering program in Toronto. These results support the SCCT's proposition that exposure is needed to generate interest, which may then lead to greater self-efficacy and positive outcome expectations, and finally, personal goal setting. In this case, interest in or applying to post-secondary programs is a clear instance of "goal setting". These positive results suggest that future research initiatives should consider how to fulfill these three SCCT elements in order to attract girls to engineering.

Spending months exploring best practices for communicating with teenage girls about their career choices, specifically in engineering, has revealed that my mother was not the only parent who shied away from introducing her daughter to engineering. Prior research reveals that engineering is a career that is misunderstood by the majority of the North American population, including parents and teachers. Because engineering is not typically associated with femininity, it is not shocking that parents are less likely to expose their female children to this career path. Also notable is the hesitance all

participants indicated when asked if they were willing to discuss their career paths. This brought me back to my time in high school when I was struggling to figure out where my own life was headed. With my memory jogged by conversations with these five teenage girls, hindsight tells me that "complicated" does not begin to describe the communication between parent and teenager, particularly when discussing a teenager's future. Perhaps, had I taken part in an extracurricular program like WEMADEIT, my mother would have seen my interest in engineering and my self-efficacy blossom, opening up lines of communication between my mother and I -- paving the way to a conversation about engineering.

WORKS CITED

AAUW.org. (2010, February). Why So Few?: Women in Science, Technology, Engineering and Mathematics. (C. Hill, C. Corbett, & A. St. Rose, Eds.)

Actua (2003) The Importance in Engaging Girls in Science and Engineering. *Canadian Engineering Memorial Foundation*. Retrieved from: http://www.cemf.ca/PDFs/Girls.pdf

Alberta Women's Science Network. (2014). Retrieved August 4, 2014, from *https://www.awsn.com/*

Amadei, B., & Sandekian, R. (2010). Model of integrating humanitarian development into engineering education. *Journal of Professional Issues in Engineering Education and Practice*, *136*(2), 84-92.

Anderson, A., and K. Gilbride (2007). The future of engineering: A study of the gender bias. McGill Journal of Education 42 (1): 103–17.

Anderson, L., & Gilbride, K. (2003). Bringing Engineering to K-12 Classrooms – Initiatives and Results. In Proceedings of 2003 ASEE Annual Conference and Exposition. Washington: ASEE

Bandura, A. (1986). *Social foundations of thought and action* (pp. 5-107). Prentice Hall: Englewood Cliffs, NJ.

Bandura, A., Barbaranelli, C., Caprara, G. V., & Pastorelli, C. (2001). Self‐efficacy beliefs as shapers of children's aspirations and career trajectories. *Child development*, *72*(1), 187-206.

Betz, D. E. (2012). My Fair Physicist? Feminine Math and Science Role Models Demotivate Young Girls. *Social Psychological and Personality Science , 3* (6).

Bong, M. (2001). Role of self-efficacy and task-value in predicting college students' course performance and future enrollment intentions. *Contemporary Educational Psychology*, 26, 553-570.

Bourdieu, P. (1989) Social Space and Symbolic Power. *Sociological Theory*, 7(1), 14-25.

Braun, V. & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology* 3(2):83. doi: 10.1191/1478088706qp063oa

Brown, J. S., & Duguid, P. (2000). *The Social Life of Information.* Boston: Harvard Business School Press.

Brown, S. D., & Lent, R. W. (Eds.). (2004). *Career development and counseling: Putting theory and research to work*. John Wiley & Sons.

Chan, A. & Fishbein, J. (2009). A Global Engineer for the Global Community. *The Journal of Policy Engagement,* 1(2). Retrieved from: http://my2.ewb.ca/site_media/static/attachments /group_topics_grouptopic/61681/Global%20Engineering.pdf

Chhin, C. S., Bleeker, M. M., & Jacobs, J. E. (2008). Gender-typed occupational choices: The long-term impact of parents' beliefs and expectations.

Cushman, E. (1999). The public intellectual, service learning, and activist research. *College English , 61* (3), 328.

Doucet, A. (2009). Gender equality and gender differences: parenting, habitus, and embodiment (the 2008 porter lecture). Canadian Review of Sociology, 46(1).

Dweck, C. S. (2007). Is Math a Gift? Beliefs That Put Females at Risk. In S. J. Ceci, & W. M. Williams, *Why aren't more women in science: Top researchers debate the evidence* (pp. 47-55). American Psychological Association.

Eccles, J. S. (1994). Understanding women's educational and occupational choices. *Psychology of women quarterly*, *18*(4), 585-609.

EngineersCanada (2013). Accreditation Criteria and Procedures. *Canadian Engineering Accreditation Board*. Retrieved from: http://www.engineerscanada.ca/sites/default/files/sites/default/files/accreditation_criteria_procedures_2013.pdf

Falcioni, J. G. (2012). Girls Love STEM. *Mechanical Engineering , 134* (4), 6.

Foor, C. E., Walden, S. E., & Trytten, D. A. (2007). "I Wish that I Belonged More in this Whole Engineering Group:" Achieving Individual Diversity. *Journal of Engineering Education*, *96*(2), 103-115.

Franck, L. S., & Noble, G. (2007). Here's an idea: ask the users! Young people's views on navigation, design and content of a health information website. *Journal of Child Health Care , 11* (4), 287-297.

Gilbride, K. A., Waalen, J. K., Kennedy, D. C., & Zywno, M. S. (1998). Discover engineering - a strategy for attracting women into engineering. Proc. CSME Forum, Toronto, ON, 112-118.

Girl Scout Research Institute. (2012). Generation STEM: What Girls Say about Science, Technology, Engineering and Math. *Girl Scouts of the USA*.

Guest, G., MacQueen, K., & Namey, E. E. (2012). Applied thematic analysis. (p. 1 - 20). United States: SAGE Publications. Retrieved from http://www.sagepub.com/upm-data/44134_1.pdf

Hackett, G., & Betz, N. E. (1995). Self-efficacy and career choice and development. In *Self-efficacy, adaptation, and adjustment* (pp. 249-280). Springer US.

Halpern, D. A. (2007). Encouraging girls in math and science. Washington, DC: *National Center for Education Research: U.S. Department of Education*

Heilbronner, N. N. (2013). The STEM Pathway for Women: What Has Changed? *Gifted Child Quarterly , 57* (1), 39 –55.

Hoh, Y. K. (2009). Using Notable Women in Environmental Engineering to Dispel Misperceptions of Engineers. *International Journal of Environmental and Science Education*. 4(2), 117-131.

Hughes, R. M., & Nzekwe, B. &. (2013). The Single Sex Debate for Girls in Science: a Comparison Between Two Informal Science Programs on Middle School Students' STEM Identity Formation. *Res Sci Educ , 43* , 1979–2007.

Huguet, P., & Régner . (2008). Stereotype Threat Among Schoolgirls in Quasi-Ordinary Classroom Circumstances. *Isabelle Journal of Educational Psychology , 99* (3), 545 – 560

Hyde, J. S., Fennema, E., Ryan, M., Frost, L. A., & Hopp, C. (1990). Gender comparisons of mathematics attitudes and affect. *Psychology of women Quarterly*, *14*(3), 299-324.

Intel (2011). Intel Survey Finds Job Variety and Earning Power Motivate U.S. Teens to Consider Engineering as a Career. *Intel Newsroom*. 12/6. Retrieved from: https://newsroom.intel.com/community/intel_newsroom/blog/2011/12/06/exposure-to-engineering-doubles-teens-career-interest

Inzlicht, M. &. Schmader T. (2011). Introduction. In *Stereotype Threat: Theory, Process, and Application.* New York: Oxford University Press.

Jagacinski, C. (2013). Women engineering students: Competence perceptions and achievement goals in the freshman engineering course. *Sex Roles, 69*(11-12), 644-657. doi:10.1007/s11199-013-0325-9

Kimball, M. M. (1989). A new perspective on women's math achievement. *Psychological Bulletin*, *105*(2), 198.

Knight, M & Cunningham, C (2004). "Draw an engineer test (DAET): Development of a tool to investigate students' ideas about engineers and engineering." *Proceedings for the American Society for Engineering Education*. Salt Lake City.

Lent, R. W., Brown, S. D., & Hackett, G. (2002). Social cognitive career theory. *Career choice and development*, *4*, 255-311.

Little, A. J., & Bernardo A. L. B. (2009). Attracting girls to science, engineering and technology: An Australian perspective. *European Journal of Engineering Education, 34*(5), 439-445. doi:10.1080/03043790903137585

Marra, R. M., Rodgers, K. A., Shen, D., & Bogue, B. (2009). Women engineering students and self-efficacy: A multi-year, multi-institution study of women engineering student self- efficacy. *Journal of Engineering Education, 98*(1), 27-38. Retrieved from http://ezproxy.lib.ryerson.ca/login?url=http://search.proquest.com/docview/217966834?accountid=13631

Nosek BA, Banaji MR, Greenwald AG. Math = male, me = female, therefore math ≠ me. Journal of Personality and Social Psychology [Internet]. 2002;83:44-59.

ONWiE, Ontario Network of Women in Engineering (2014). Retrieved August 4, 2014 from *http://www.onwie.ca/*

Passino, K. M. (2009). Educating the humanitarian engineer. *Science and engineering ethics*, *15*(4), 577-600.

Schensul, J. J., & Berg, M. (2004). Youth Participatory Action Research: A Transformative Approach to Service-Learning. *Service-Learning and Anthropology , 10* (3), 76-88.

Schneider, J., Leydens, J. A., & Lucena, J. (2008). Where is 'Community'?: Engineering education and sustainable community development. *European journal of engineering education*, *33*(3), 307-319.

Siann, G., & Callaghan, M. (2001). Choices and barriers: Factors influencing women's choice of higher education in science, engineering and technology. *Journal of Further and Higher Education*, 25(1), 85-95.

Sinkele, C. N., & Mupinga, D. M. (2011). The effectiveness of engineering workshops in attracting females into engineering fields: A review of the literature. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 84*(1), 37-42. doi:10.1080/00098655.2010.496812

Spelke, E., & Grace, A. (2006). Abilities, Motives, and Personal Styles. *61* (7), 725 726.

Tartre, L. A., & Fennema, E. (1995). Mathematics achievement and gender: A longitudinal study of selected cognitive and affective variables [Grades 6–12].*Educational studies in mathematics*, *28*(3), 199-217.

The Extraordinary Women Engineers Project [EWEP] (2005). The Extraordinary Women Engineers Project Final Report, April 2005. *WIE*. Retrieved from: http://wie.engineering.ucdavis.edu/pages/EWEPFinal.pdf

The National Academies Press. (2010). Rising above the gathering storm, revisited: Rapidly approaching Category *5*. Retrieved on 02/19/2014 from: http://www.uic.edu/home/Chancellor/risingabove.pdf

Tuerk, A. L., & Lee, K. H. (2014). The evolving engineer. *AIChE Journal*, *60*(6), 1956-1963.

U.S. Department of Commerce . (2011). Women in STEM: A gender gap to innovation. Retrieved on 02/19/2014 from: http://www.esa.doc.gov/Reports/women-stem-gender-gap-innovation

Watt, H. M., & Eccles, J. S. (2008). *Gender and occupational outcomes: Longitudinal assessments of individual, social, and cultural influences*. American Psychological Association.

Women in Science and Engineering. (2014). Retrieved August 4, 2014 from *http://www.wiseatlantic.ca/*

Zywno, M.S.; Gilbride, K.A.; Hiscocks, P.D.; Waalen, J.K.; Kennedy, D.C., Attracting women into engineering-a case study, *IEEE Transactions on Education*. 42 (4), Nov 1999. doi: 10.1109/13.804556

APPENDICES

Appendix 1.0: Preliminary Interview Questions

Appendix 1.0: Preliminary Interview Questions

1) *What's your favourite subject of study in school? What do you like about it?* (Note to Interviewer: Use this as a "get to know you" question – make them feel comfortable.)
2) *Would you describe yourself as good at math and science?* (Note to Interviewer: Probe about whether or not the student likes math and/or science. What was their last grade in Math/Science?)
3) *In your own words, what is the job of an Engineer?* (Note to Interviewer: Let the student know that there isn't one correct answer. Ask them to describe the occupation to the best of their ability.)
4) *Picture an Engineer in front of you right now - what do they look like? Describe them to me.* (Note to Interviewer: probe the interviewee for details… male or female? What are they wearing? How old etc.)
5) *When this Engineer finishes work for the day, where do they go and what do they do? What does this person do for fun?* (Note to Interviewer: Allow time to answer this question – encourage creativity.)
6) *What is your dream job? Why does it appeal to you?* (Note to Interviewer: If the interviewee is struggling, list these elements as examples: Making lots of money, Liking the people you work with etc.)
7) *Do you have any family members who took a degree in engineering?*
8) *Has a teacher ever talked to you about engineering? Has a family member? Has anyone else?* (Note to Interviewer: Prompt for anyone who's talked to them about Engineering)
9) *Would you be interested in finding out more about engineering?*
10) *Would you be interested in applying to Engineering school? Why or why not?* (Note to Interviewer: Keep this casual, prompt them for their reasons why. It's possible that the student will say yes simply to appease the interviewer - emphasize answering honestly!)
11) *How does the prospect of being an engineer make you feel?*
12) *Do you think girls are excited about Engineering? Why do you think this is?* (Note to Interviewer: Allow lots of time for interviewee to think – make this conversational. Be appreciative of their ideas. Tell them that even after they suggest an idea, they can take it back if they change their mind)
13) *When was the last time you talked to someone about engineering or posted on social media about engineering (if ever)?* (Was it positive?)

Appendix 2.0: Follow-Up Interview Questions:

Appendix 2.0: Follow-Up Interview Questions

1) *Is engineering more or less appealing to you after taking part in the YTT (be honest!)*
2) *If you saw a cool article or meme about engineering, would you post it on social media to share with your friends? Why or why not?*
3) *Do you think that your friends could get excited about Engineering? (*Prompt: Why/Why not? Can you think of any examples based on what you've heard your friends say about engineering?)
4) *In the last month, have you talked to anyone about engineering?* (Prompt: How many times? Were they positive/negative? Tell me about these conversations.)
5) *Do you have any friends who you think would be good engineers? If so - now that you've learned more about engineering, are you going to encourage them to apply to engineering school?*
6) *What did you think of engineering before you joined the YTT?*
7) *What do you think about engineering now? Has anything changed?*
8) *How would you describe your experience with the YTT?*
9) *Have you had any thoughts about your future plans since taking part in the YTT? If so, what changes have you thought about?*

Appendix 3.0: REB Letter of Approval

RYERSON UNIVERSITY
RESEARCH ETHICS BOARD

To: Miri Makin
FCAD, Masters of Professional Communication
Re: REB 2014-072: Changing Gears: Communicating the Benefits of Engineering to Girls
Date: March 19, 2014

Dear Miri Makin,

The review of your protocol REB File REB 2014-072 is now complete. The project has been approved for a one year period. Please note that before proceeding with your project, compliance with other required University approvals/certifications, institutional requirements, or governmental authorizations may be required.

This approval may be extended after one year upon request. Please be advised that if the project is not renewed, approval will expire and no more research involving humans may take place. If this is a funded project, access to research funds may also be affected.

Please note that REB approval policies require that you adhere strictly to the protocol as last reviewed by the REB and that any modifications must be approved by the Board before they can be implemented. Adverse or unexpected events must be reported to the REB as soon as possible with an indication from the Principal Investigator as to how, in the view of the Principal Investigator, these events affect the continuation of the protocol.

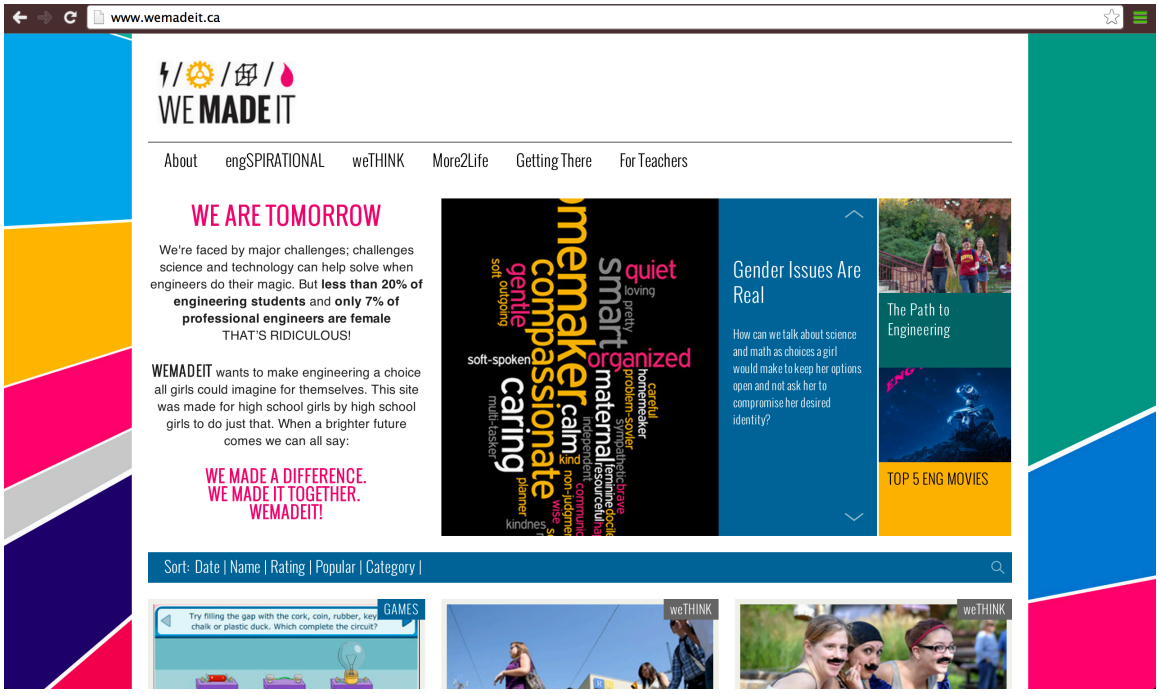
Finally, if research subjects are in the care of a health facility, at a school, or other institution or community organization, it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and approvals of those facilities or institutions are obtained and filed with the REB prior to the initiation of any research.

Please quote your REB file number (REB 2014-072) on future correspondence.

Congratulations and best of luck in conducting your research.

Lynn Lavallée, Ph.D.
Chair, Research Ethics Board

Appendix 4.0



WEMADEIT.ca Homepage