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Math Self-efficacy and the Likelihood of Pursuing a STEM-Based Career: a Gender-Based Analysis

Tamara A. Franz-Odendaal ·
Karen A. Blotnicky · **Phillip Joy**

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Abstract The attitudes teenagers have towards Math, as well as their knowledge of Science, Technology, Engineering and Math (STEM)–based careers will affect their likelihood of pursing these careers in the future. The purpose of this study was to examine the attitudes that youth (girls and boys) aged 12–14 hold towards Math, their knowledge of Math, and Science requirements for future careers as well as their likelihood of choosing a STEM-based career. This research also examined the responses of girls who attended a week-long intensive Science summer camp compared with those who did not attend this camp. To do this, students' attitudes and knowledge were explored using a gender-based analysis (GBA) in four sample groups: (1) public school boys, (2) public school girls, (3) public school girls who do well in math, and (4) a specialized sample of girls who had attended a female-only Science summer camp. Our results show that more grade 7 girls in Nova Scotian public schools feel tense doing Math problems compared with similarly aged boys, yet the average self-rating of getting good marks, learning Math quickly, and looking forward to Math were similar for girls and boys. Furthermore, girls had a better knowledge of careers that required Math and/or Science than boys. In relation to the Science camp, significantly more girls attending the Science camp indicated that they would be very likely to pursue a STEM career in the future, compared with girls, with equally good Math grades, in the non-camps group. These findings show that enabling girls to interact with female STEM professionals and to attend an all-girls Science dedicated camp significantly impacts their interest in STEM professions and is a concrete way in to break down stereotypes in male-dominated fields.

Résumé Les attitudes des adolescents envers les mathématiques, ainsi que leurs connaissances des carrières dans les sciences, la technologie, l'ingénierie et les mathématiques (STEM) influeront sur la probabilité qu'ils entreprennent une carrière dans ces domaines dans l'avenir. Le but de cette étude était

T. A. Franz-Odendaal (✉)
Department of Biology, Mount Saint Vincent University, Halifax, NS B3M 2J6, Canada
e-mail: Tamara.Franz-Odendaal@msvu.ca

K. A. Blotnicky
Department of Business Administration, Tourism and Hospitality Management, Mount Saint Vincent University, Halifax, NS B3M 2J6, Canada

P. Joy
Applied Human Nutrition, Mount Saint Vincent University, Halifax B3M 2J6 NS, Canada

d'examiner les attitudes des jeunes (filles et garçons) âgés de 12 à 14 ans à l'égard des mathématiques, leur connaissance des exigences en mathématiques et en sciences pour de futures carrières, ainsi que la probabilité qu'ils choisissent une carrière dans les STEM. Cette étude a également examiné les réponses des filles ayant participé à un camp d'été scientifique intensif d'une semaine comparativement à celles qui n'ayant pas participé à ce camp. Pour ce faire, les attitudes et les connaissances des élèves ont été étudiées à l'aide d'une analyse comparative entre les sexes (ACS) dans quatre échantillons : 1) garçons des écoles publiques, 2) filles des écoles publiques, 3) filles des écoles publiques qui réussissent bien en mathématiques et 4) un échantillon spécialisé de filles ayant participé à un camp d'été scientifique réservé aux filles. Nos résultats indiquent que davantage de filles de septième année dans les écoles publiques de la Nouvelle-Écosse se sentent tendues lorsqu'elles font des problèmes de mathématiques comparativement aux garçons d'âge similaire. Cependant, l'auto-évaluation moyenne pour obtenir de bonnes notes, apprendre les mathématiques rapidement et avoir hâte de faire des mathématiques était similaire pour les filles et les garçons. De plus, les filles avaient une meilleure connaissance que les garçons des carrières exigeant les mathématiques, les sciences, ou les deux à la fois. Par ailleurs, beaucoup plus de filles ayant participé au camp scientifique ont indiqué qu'elles seraient très susceptibles de faire carrière dans les STEM dans l'avenir comparativement aux filles du groupe n'y ayant pas participé dont les notes en mathématiques étaient aussi bonnes. Ces résultats indiquent que le fait de permettre aux filles d'interagir avec des femmes professionnelles des STEM et de participer à un camp scientifique réservé aux filles a un effet important sur leur intérêt pour les professions en STEM et constitue un moyen concret de briser les stéréotypes dans les domaines dominés par les hommes.

Keywords Gender-based analysis · Girls · Science · Technology · Engineering · Mathematics · STEM-career choices

Introduction

Several studies document a general decline in STEM (Science, Technology, Engineering and Math) interest from elementary school to late high school (Agard, 2017; Chachashvili-Bolotin et al., 2019; DeCoito, 2016; Jaremus et al., 2019; Murphy et al., 2019; VanLeuvan, 2004; Wells et al., 2007). Research indicates that within some STEM disciplines women are better represented than they were in the past, including life sciences and chemistry but are still very under-represented in STEM fields such as engineering, computing, and physics. For example, in 2016 the following distributions for females working in various STEM fields in Canada were reported: 49% in agriculture, 38% in biology, 27% in general science, 36% in math/computer science, and only 17% in engineering (Blotnicky et al. 2018). Regardless of the specific area of STEM, recommendations to increase the number of women in STEM are universal for innovation in science and technology (Modi et al., 2012).

DeCoito (2016) highlights the lack of information relating to STEM choice, gender, and other knowledge regarding who pursues STEM careers within the Canadian context and recommends more research into these areas to strengthen STEM education and careers within Canada. Maltese and Tai (2011) show that the choice to continue STEM education is made in high school and that this choice is related to their interest in Math and Science, rather than their performance in Math and Science. However, other studies have shown that students may have limited understanding of STEM careers, which affects their perceptions of these careers (Masnick et al., 2010).

Career decision-making is a complex process involving many factors that are continually changing. There have been calls for more research into understanding why student interest in STEM subjects or careers changes (and often declines) prior to entering college (Fouad & Smith, 1996; van Aalderen-Smeets & van der Molen, 2018; VanLeuvan, 2004). In their article exploring why students choose and reject science, Palmer et al. (2017) found that many factors, reasons, experiences, and influences are involved in

career decision-making in STEM. Specifically, they noted that previous engagement in science, perceptions of the usefulness of science, socio-economic factors, gender preferences, and the decreased popularity of science as a subject are some of the key determinants of choice for STEM careers. Four intrinsic or personal factors and five extrinsic or external factors were identified that interact with these determinants. The four intrinsic factors are attitudes, interests and engagement, ability and self-efficacy, and gender. The five extrinsic factors are socioeconomic, persons of influence, teaching and curriculum, careers, and various logistics of choice.

The attitudes students have towards mathematics will affect their interests, course selections in high school, and likelihood to pursue a STEM-based career (Ball et al., 2017; Cutumisu & Bulut, 2017; Lent et al., 2002; Modi et al., 2012; van Aalderen-Smeets & van der Molen, 2018). However, the effects of self-efficacy and stereotypes will also affect career aspirations and career choice (Lent et al., 2002). Self-efficacy refers to an individual's belief in their capacity to execute behaviours and reflects confidence in their ability to control their own behaviour, motivation, and social environment (Bandura, 1986).

The effect of stereotype threat within STEM fields is not equal for boys and girls and has an enormous impact on their self-efficacy and attitudes towards Math. For example, Nguyen and Ryan (2008) conducted a meta-analysis of the effect of negative stereotyping on women and minorities. They found that contextual cues impair the performance of individuals who belong to negatively stereotyped groups. This "stereotyped threat effect on performance" occurs when there is underrepresentation of one's group in another group (Sekaquaptewa & Thompson, 2003). For example, the male-dominated STEM fields negatively impact the self-efficacy of women who may have aspirations to enter these fields. Previous research has already demonstrated how performing under the pressure of negative stereotypes can influence not only test scores but also attitudes and aspirations for women working in math and other areas of STEM (Dardenne et al., 2007; Schuster et al., 2015; Davies et al., 2002). Schuster and Martiny (2017) conducted two studies on stereotyping, one involving undergraduate women and the other involving high school students. They found that undergraduate women expect more negative and less positive effects as well as a heightened sense of threat in a setting that activates a stereotype compared with a non-stereotype activating setting. The same was not true for a group of males presented with the same stereotype activating information. In their study with high school students, Schuster and Martiny (2017) found that female high school students aspired less to courses that were seen as more stereotypically male while young males were not affected. Interestingly, young women's self-efficacy was not altered in this study. Nevertheless, young women even with positive self-efficacy in their subject area did not aspire to those subjects perceived as being stereotypically male.

The importance of self-efficacy in developing career interests and forming academic goals has been well supported by theory-based models such as the Social Cognitive Career of Lent et al. (1994) and by Eccles' (1994) model of achievement-related choices. Recent findings show that self-efficacy along with understanding and knowledge of STEM careers are significant factors in whether or not adolescents pursue STEM careers (Compeau, 2016; Nugent et al., 2015; Schumacher et al., 2009; Dabney et al., 2012; Zhang & Barnett, 2015; Sahin et al., 2014; Sjaastad, 2012). Research has also shown that young women have lower self-efficacy in STEM-based subjects during high school (Heilbronner, 2009) and that both interest and motivation tend to wain during these years (Murphy & Beggs, 2003; Mangu et al., 2015). This ultimately leads to a lower self-efficacy score that can pull girls away from pursuing STEM fields. Crozier (1999) concluded that more attention should be paid to examine the career development of women from a relational context enabling an enhanced understanding of career choice, career development, multiple life roles, decision-making, and career success. Frome et al. (2006) suggest that societal roles also play a role in students' self-efficacy and interest. In support of this, Damaske (2011) notes that the relationship women have with work changes at different stages of adulthood and are impacted by socio-economic class, societal norms, and race. In other words, the key determinants and the intrinsic and extrinsic factors that impact career decisions identified by Palmer et al. (2017) are likely different for women.

Study Purpose and Research Questions

The purpose of this study was to examine the attitudes that youth aged 12–14 hold towards Math, their knowledge of Math, and Science requirements for future careers as well as their likelihood of choosing a STEM-based career. These attitudes and knowledge were explored using a gender-based analysis (GBA) in four sample groups: (1) public school boys, (2) public school girls, (3) public school girls who do well in math, and (4) a specialized sample of girls who had attended a female-only Science summer camp. We selected Math because previous research has shown that individuals with high math capabilities were most likely to pursue STEM careers (e.g. Wang et al., 2013; Blotnicky et al., 2018). Our goal was to conduct a comparative analysis across the four sample groups mentioned above. This gender-based analysis (GBA) was conducted on the public school dataset from a previous study that focused on middle students' perceptions of STEM subjects, STEM careers, and engagement in STEM activities (Franz-Odendaal et al., 2016; Blotnicky et al., 2018), with the addition of an additional cohort (namely, girls who attended a week-long Science camp in the summer months). We also compared responses between girls engaged in the Science camp with girls in a control group who report equally good Math grades but who did not attend the Science camp.

The research questions (RQ) below were created to guide this exploratory study based on the literature and previous studies with this Canadian middle school cohort (Franz-Odendaal et al., 2016; Blotnicky et al., 2018):

RQ1: Do girls and boys in middle school differ in their attitudes towards Math? Do these students similarly rank Math as a favourite subject?
RQ2: Do attitudes towards Math differ between girls attending public school versus those attending a specialized Science camp, where girls in both groups report doing well in Math? Do these groups similarly rank Math as a favourite subject?
RQ3: Do girls and boys in middle school differ in their knowledge of the high school Math/Science requirements for studying STEM-based careers?

Prior to exploring our next set of questions related to knowledge of requirements for and likelihood of exploring STEM-based careers, we asked students whether they actually knew what engineers did for a living. The answers to this question provide important contextual insight into our analyses for the next three research questions.

RQ4: Do middle school girls who are comfortable with Math differ from Science camp girls in their knowledge of the high school Math/Science requirements for studying STEM careers?
RQ5: Are there differences between middle school boys and girls in their likelihood of choosing STEM-based careers in the future?
RQ6: Are there differences between public school girls who are comfortable in Math and Science camp girls in their likelihood of choosing STEM-based careers?

Methodology

The Sample

This study undertakes a gender-based analysis of a subset of data previously analysed (Blotnicky et al., 2016). Specifically, we compare the results from two sets of data collection: a Nova Scotia public school grade 7 cohort (part of our previous study, Blotnicky et al., 2016) and a sample of girls who attended a girls-

only week-long Science summer camp. The public school cohort included students from randomly selected schools within the province. Data was collected from two surveys administered from 2013 to 2015. This research was approved by Mount Saint Vincent University's Research Ethics Board (File # 2011-106) and permissions were obtained from school board superintendents and parents/guardians.

The Science camp cohort consisted of girls about to enter grade 7, or having just graduated from grade 7, who attended a Science camp in Halifax, Nova Scotia, over a five-year period between 2012 and 2016. There was no selection process to admit girls to the camp but there was a modest camp fee. These students completed the same survey as the Nova Scotia public school cohort with parent/guardian consent. Girls attending the Science camp could only complete the survey once regardless of how many times they attended the Science camp throughout the five-year study. The survey was administered to the girls attending the Science camp on the final day of the first Science camp they attended. This Science camp consisted of hands-on activities that were presented in a way that would appeal to girls (i.e. without male stereotyping) and involved face-to-face interactions with local women who had completed post-secondary education in STEM and who were currently working in STEM fields.

This study included two unique comparisons of the survey data. The first compared girls and boys in the NS public school grade 7 cohort. The responses in the grade 7 cohort were unique responses without any duplicate surveys. There were 207 girls and 176 boys in the NS grade 7 cohort for a total sample of 383 students. We will refer to this dataset as the public school group in which we compare the responses from girls versus boys.

The second comparison was within a specialized profile group of girls. Here we compared data from public school girls attending the week-long Science camp compared with a subset of the grade 7 girls in the public school cohort who did not attend this Science camp. We used one question in our survey (Do you get good marks in Math) to select this subset of grade 7 girls from the public school sample for the comparison. Only girls who responded "strongly agree" or "agree" on a five-point Likert scale were included in the Math Profile group. There were 158 (67.8%) girls in the Math Profile group and 75 (32.2%) girls in the Science camp cohort for a total of 292 girls in this analysis.

Measures

All measures used were previously reported in detail in earlier analyses of the data (Franz-Odendaal et al., 2016; Blotnicky et al., 2018); however, earlier analyses did not include a gender-based analysis or an analysis of girls attending a Science camp. The measures are repeated here for clarity.

Attitudes Towards Math

Students were asked to describe their attitudes about Math by rating the subject on five criteria using a five-point Likert scale ranging from 1-strongly agree to 5-strongly disagree. The five criteria evaluated included the following statements:

1. I get good marks in (Math)
2. I learn (Math) quickly
3. I look forward to my (Math) classes
4. I get very tense doing (Math) problems
5. I feel helpless when doing a (Math) problem

Students were then asked to rank their favourite subjects from 1-most favourite to 7-least favourite. The subjects included in the ranking were General Science, Physics, Chemistry, Biology, Math, History/Social Studies, and English. For purposes of this current analysis, only the rankings for Math were examined.

Career Knowledge and Likelihood of Pursuing a STEM Career

In order to evaluate the students' understanding of career requirements, several questions were asked, including qualitative and quantitative type questions. Qualitatively, students were asked to describe in their own words what engineers do for a living since this is a field that is greatly under-represented by women in Canada. Their answers were anecdotal, unaided, and open-ended. The text responses were then thematically coded using an Excel spreadsheet. Codes were reviewed between all researchers and underlying themes were finalized after the review. Quantitively, a list of 24 occupations (Blotnicky et al., 2018) was provided to students and they were asked to indicate whether or not they thought that the occupation required Math and/or Science knowledge in high school. Students also had the option of choosing "uncertain" if they were not sure of the answer. Finally, students were asked how likely they were to pursue a STEM-based career using a four-point Likert scale from 1-very likely to 4-very unlikely.

Data Analysis

Quantitative data analysis included examining the frequencies for all variables and Likert scale responses and by comparing average Likert scale ratings between comparison groups for Math attitudes and the likelihood of pursuing a STEM career. Medians were also compared for favourite subject rankings. Average scale ratings were subject to significant testing using *t* tests or ANOVA. Chi-square analysis and differences between proportions (*Z*-tests) were used to determine statistically significant differences between groups. Qualitative data analysis was conducted on open-ended questions. Anecdotal responses were grouped thematically and coded for entry into the quantitative database. The qualitative coded data was then analysed as part of the larger quantitative study, enabling the examination of qualitative responses by gender, group, and grade.

Results

Attitudes Towards Math

Our first part of research question one explored whether the boys and girls differ in their attitudes towards Math. The public school boys were reasonably confident in their Math abilities. Their average scale rating on the Likert scale ranging from (1) strongly agree to (5) strongly disagree was 1.91 (SD = 1.197). They were somewhat less confident in their ability to learn Math quickly ($M = 2.10$, SD = 1.205) and most did not necessarily look forward to Math ($M = 2.66$, SD = 1.382). However, the boys were inclined to disagree with the statements that they felt very tense doing Math problems ($M = 3.67$, SD = 1.343) or feeling helpless when doing Math problems ($M = 3.84$, SD = 1.437).

Public school girls were also reasonably confident in their abilities in Math. Their average Likert scale rating for getting good marks in Math was 1.92 (SD = 1.152). They were somewhat less confident in their ability to learn Math quickly ($M = 2.25$, SD = 1.223) or whether they looked forward to Math classes ($M = 2.85$, SD = 1.367). When asked if they got tense or felt helpless doing Math problems, public school girls did not agree, with average ratings of 3.39 (SD = 1.367) and 3.95 (SD = 1.354) respectively.

A comparison between attitudes towards Math for the public school boys and girls showed that there was only one measure that was significantly different between the genders. That is, girls were statistically less likely than boys to say that they get very tense doing Math problems (Table 1). This indicates that girls are overall more confident in doing Math problems than boys. It is important to note that both genders disagree with the statement that they get very tense doing Math problems suggesting that the results are different in a practical sense, despite the fact that they differ statistically. The results are summarized in Table 1.

Table 1 Comparison of attitudes towards math, girls versus boys. Average ratings ± standard deviations are shown. Numbers in brackets are the number of respondents. Rating scale: (1) strongly agree to (5) strongly disagree. Asterisk (*) indicates statistically significant differences ($t = 2.2023$, df = 368, $p = 0.044$)

Criteria	Public school boys	Public school girls
I get good marks in Math	1.91 ± 1.197 ($n = 173$)	1.92 ± 1.152 ($n = 205$)
I learn Math quickly	2.10 ± 1.205 ($n = 172$)	2.25 ± 1.223 ($n = 203$)
I look forward to my Math classes	2.66 ± 1.382 ($n = 172$)	2.85 ± 1.418 ($n = 205$)
I get very tense doing Math problems	3.67 ± 1.343 ($n = 168$)*	3.39 ± 1.367 ($n = 202$)*
I feel helpless when doing a Math problem	3.84 ± 1.437 ($n = 164$)	3.95 ± 1.354 ($n = 201$)

In order to assess whether attitudes towards Math differed between a breakout group of Math-confident girls from the public school sample and the Science camp girls (research question two), we created a Math Profile group from the public school sample by selecting girls that gave ratings of 1 or 2 on the Likert scale, indicating that they agreed that they got good marks in Math (see Methods, RQ2). These girls agreed that they learned Math quickly ($M = 1.86$, SD = 0.939), but were somewhat less inclined to look forward to their Math classes ($M = 2.61$, SD = 1.381). They did not get tense doing Math problems ($M = 3.64$, SD = 1.319). They also did not feel helpless when doing Math problems ($M = 4.29$, SD = 1.102).

The sample of girls who attended a Science camp agreed that they learned Math quickly ($M = 1.77$, SD = 0.967) and they were somewhat less inclined to look forward to their Math class ($M = 2.45$, SD = 1.244). They did not get tense while doing Math problems ($M = 3.69$, SD = 1.303) nor did it make them feel helpless ($M = 4.29$, SD = 1.160).

A comparison of girls Math Profile group with girls in the Science camp group revealed that there were no statistically significant between the two groups regarding their attitudes towards math. The results are shown in Table 2. With this similar attitude towards Math confirmed, we then used these two groups to further explore their other responses in the surveys.

Favourite Ranking of Math

As part of research question one, we also wanted to determine whether boys and girls rank Math as a favourite subject similarly. Students were asked to rank subjects based on their most favourite (1) to least favourite (7). The public school boys ranked Math from 1 to 7 with 42.3% ranking it as their favourite (1), followed by 18.2% ranking it second and 19.7% ranking it third. These rankings show that the boys considered Math to be one of their more liked subjects in school. The average overall ranking for Math was 2.26 (SD = 1.395) out of 7 with a median rank of 2/7.

Thirty-four percent of public school girls rated Math as their most favourite subject (1) followed by 28.2% who rated it second. Twenty-four percent rated Math as their third favourite subject. Overall, over 76% of public school girls rated Math in their top three favourites. The average overall ranking of Math as a favourite course for public school girls was 2.45 (SD = 1.328) with a median rank of 2/7.

The ranking of Math as a favourite course was consistent for both boys and girls with identical median rankings and no significant differences between average rankings. The results are shown in Table 3.

Part of research question two explored whether the Math Profile group and the Science camp girls rank Math as a favourite subject similarly. The breakout Math Profile group of girls rated Math among their most favourite subjects. Over 35% rated it first, followed by 20.1% who rated it second and 26.6% who rated it third. Overall, 82% of girls in the Math Profile group rated Math in their top three favourite courses. The median rank of Math in this sample group was 2 and the average math favourite rank was 2.35 (SD = 1.28).

The Science camp girls also rated Math highly as a favourite subject. Nearly 34% rated it as their top favourite (1), followed by 28.2% who rated it second, and 23.9% who rated it third. Overall, more than 85%

Table 2 Scale ratings for attitude statements regarding math for the Math Profile girls versus Science camp girls. Average ratings ± standard deviations are shown. Numbers in brackets are the number of respondents. Rating scale: (1) strongly agree to (5) strongly disagree for all of questions 2 through 5. No statistically significant differences were present

Criteria	Math Profile girls	Science camp girls
I get good marks in Math	Scale values = 1 or 2 (agreement)	
I learn Math quickly	1.86 ± 0.939 (n = 158)	1.77 ± 0.967 (n = 75)
I look forward to my Math classes	2.61 ± 1.381 (n = 158)	2.45 ± 1.244 (n = 75)
I get very tense doing Math problems	3.64 ± 1.319 (n = 168)	3.69 ± 1.303 (n = 75)
I feel helpless when doing a Math problem	4.29 ± 1.102 (n = 164)	4.29 ± 1.160 (n = 75)

of Science camp girls rated Math in their top three favourite courses. The median rank of Math in the Science camp group was 2 with an average rank of 2.20/7 (SD = 1.09).

The ranking of math as a favourite course was consistent for both girls in the Math Profile group and the Science camp group with identical median rankings and no significant differences between average rankings. This once again establishes that these two groups have similar attitudes towards Math. The results are shown in Table 4.

Summary of Math Attitudes and Perceptions

The data above shows that boys and girls similarly ranked Math as a favourite subject; however, girls appear to be more confident in doing Math problems (research question one). Furthermore, the data shows that the Math Profile group and the Science camp group of girls have similar attitudes towards Math. This latter finding is not surprising as we purposefully created the Math Profile group this way so that we could analyse RQ4-6 meaningfully.

Career Knowledge and Understanding

Knowledge of What Engineers Do in Their Jobs

Since Engineering is a field that is greatly under-represented by women at both the post-secondary level and as professional engineers, we sought to determine whether boys and girls have different perspectives about Engineering. Students were asked to describe, in an open-ended question, what engineers do in their jobs. In

Table 3 Favouritism rankings for math in the public school group—girls versus boys. Both number of respondents and percentage of respondents are shown. Average ranking and standard deviation are also given

Ranking	Public school boys	Public school girls
1-most favourite	58 (42.3%)	62 (34.1%)
2	25 (18.2%)	33 (18.1%)
3	27 (19.7%)	44 (24.2%)
4	20 (14.6%)	33 (18.1%)
5	3 (2.2%)	6 (3.3%)
6	2 (1.5%)	4 (2.2%)
7-least favourite	2 (1.5%)	0 (0%)
Average ranking ± standard deviation	2.26 ± 1.395 (n = 137)	2.45 ± 1.328 (n = 182)
Median rank	2	2

Table 4 Favouritism rankings of math for Math Profile girls versus Science camp girls. Both number of respondents and percentage of respondents are shown. Average ranking and standard deviation are also given

Ranking	Math Profile girls Number (%)	Science camp girls Number (%)
1-most favourite	49 (35.3%)	24 (33.8%)
2	28 (20.1%)	20 (28.2%)
3	37 (26.6%)	17 (23.9%)
4	18 (12.9%)	9 (12.7%)
5	4 (2.9%)	1 (1.4%)
6	3 (2.2%)	0 (0.0%)
7-least favourite	0 (0.0%)	0 (0.0%)
Average ranking ± standard deviation	2.35 ± 1.28 ($n = 139$)	2.20 ± 1.09 ($n = 71$)
Median rank	2	2

the public school sample, five themes emerged. These themes included (1) building (fixing) things, (2) designing (inventing, solving, managing), (3) making the world a better place, (4) Math/Science, and (5) not knowing what engineers do. These themes were created through the students' own responses to the question of what they believe engineers do and reflect their understanding of this career at this point in their education. Examples of the students' qualitative responses appear in Table 5.

The most popular theme among public school boys was building (fixing) things (63.1%). Twenty-seven percent of the boys also said that engineers design (invent, solve, manage). Less than 4% said that engineers did Math or Science or made the world a better place. Nearly 7% of boys did not know what engineers did.

Among public school girls, the most important theme for what engineers said was building (fixing) things (56%) followed by designing (invent, solve, manage) (17.4%). Over 8% of public school girls said that engineers did Math or Science and over 3% said that engineers make the world a better place. Nearly 20% of girls did not know what engineers did. By way of comparison, there were no statistically significant differences between public school boys and girls regarding building/fixing things and making the world a better place. However, two of the five themes had statistically significant differences based on sex. These were designing and Math/Science. More boys than girls said that engineers designed things (27.4% versus 17.4%) ($\chi^2 = 5.571$, df = 1, $p = 0.018$) and more girls than boys said that engineers did Math and Science (8.2% versus 2.2%) ($\chi^2 = 6.668$, df = 1, $p = 0.010$). There were also statistically significant differences regarding the percentage of students that did not know what engineers did. More girls than boys said they

Table 5 Qualitative responses describing what engineers do for a living

Theme	Examples of students' responses
Build Things	"They work on things and fix them" Used phrases like build, fix, make things work including a trains, metal, machines, structures, cars, ships, planes
Design Things	"Design buildings to be safe" Used phrases like invent, design, create, plans
Don't Know	"I don't know, nor do I care"
Math/Science	"Engineers use science and math to design materials and structures" Used phrases like math, science, technology, electricity, code programs
Make the World Better	"Engineers design structures and solve problems" Used phrases like make society better, do awesome things, work with other people, solves problems

Table 6 Comparison of responses describing what engineers do for a living for the public school group—girls versus boys. Both number of respondents and percentage of respondents are shown for each theme. Asterisk (*) indicates differences are statistically significant

Theme	Public school boys ($n = 179$)	Public school girls ($n = 207$)	Significance test (chi-square, df, p value)
(1) Building (fixing) things	113 (63.1%)	116 (56.0%)	Not statistically significant
(2) Designing (invent, solve, manage)*	49 (27.4%)	36 (17.4%)	5.571, df = 1, $p = 0.018$
(3) Don't know*	12 (6.7%)	41 (19.8%)	13.913, df = 1, $p = 0.000$
(4) Math/Science*	4 (2.2%)	17 (8.2%)	6.668, df = 1, $p = 0.010$
(5) Make the world a better place	6 (3.4%)	7 (3.4%)	Not statistically significant

did not know what engineers did (19.8% versus 6.7%) ($\chi^2 = 13.913$, df = 1, $p = 0.000$. The results appear in Table 6.

The most prevalent theme for what engineers did for the Math Profile group was building (fixing) things with 58.9% of responses. This was followed by designing (invent, solve, manage) with 19.6% of girls. Only 8.9% of the Math Profile group said that engineers did Math and Science and 4.4% said engineers made the world a better place. Over 17% of Math Profile girls said they did not know what engineers did.

The five major themes were also seen in the Science camp cohort. The main theme emerging from the Science camp girls for what engineers did was building (fixing) things (58.9%), followed by designing (invent, solve, manage) with 34.4%. Over 12% of the Science camp girls said that engineers made the world a better place and 3% said engineers did Math and Science.

Comparison of the Math Profile group and the Science camp group revealed that there were statistically significant differences for three out of the four themes. These included building (fixing) things, designing (invent, solve, manage), and making the world a better place. Nearly 59% of Math Profile girls said that engineers built or fixed things compared with 42.2% of Science camp girls ($\chi^2 = 5.099$, df = 1, $p = 0.024$). Over 34% of Science camp girls believed that engineers designed things compared with half that number (19.6%) of Math Profile girls ($\chi^2 = 5.456$, df = 1, $p = 0.019$). Three times the number (12.5%) of Science camp girls believed that engineers made the world a better place compared with 4.4% of girls in the Math Profile group ($\chi^2 = 4.078$, df = 1, $p = 0.040$). However, there were no statistically significant differences regarding engineers doing Math or Science and there was no significant difference in the percentages from each group that did not know what engineers did. The results appear in Table 7.

Career Knowledge

Table 7 Comparison of responses describing what engineers do for a living for the Math Profile group versus Science camp. Both number of respondents and percentage of respondents are shown for each theme. Asterisk (*) indicates differences are statistically significant

Theme	Public school girls ($n = 158$)	Science camp girls ($n = 64$)	Significance test (chi-square, df, p value)
(1) Building (fixing) things*	93 (58.9%)	27 (42.2%)	5.099, df = 1, $p = 0.024$
(2) Designing (invent, solve, manage)*	31 (19.6%)	22 (34.4%)	5.456, df = 1, $p = 0.019$
(3) Don't know	28 (17.7%)	7 (10.9%)	Not statistically significant
(4) Math/Science	14 (8.9%)	2 (3.1%)	Not statistically significant
(5) Make the world a better place	7 (4.4%)	8 (12.5%)	4.078, df = 1, $p = 0.040$

Research question three (RQ3) examined whether girls and boys differ in their knowledge of the high school Math/Science requirements for studying STEM-based careers, and research question four (RQ4) examined this within the Math Profile group and Science camp girls. A list of 24 occupations was provided to students and they were asked to indicate whether they believed the occupation required Math/Science courses in high school. The percentage of students who correctly classified each career as whether or not they required Math/Science in high school was noted to indicate their knowledge about preparation for each career.

The top five careers correctly classified by public school boys included mechanical engineer (65.5%), teacher (63.4%), computer hardware engineer (58%), geologist (57.7%), and landscaper (51%). The bottom five careers, those that were incorrectly classified by the most boys, were graphic artist (30.1%), child/youth worker (28.8%), counselor (27.5%), conservationist (25.9%), and journalist (22.9%).

The top five careers correctly classified by public school girls included teacher (78.8%), veterinarian (72.8%), pharmacist (70.8%), medical technician (65.9%), and mechanical engineer (64%). The bottom five careers that were incorrectly classified by the most public school girls included forensic analyst (36.5%), graphic artist (35.6%), counselor (35.1%), journalist (24.6%), and conservationist (24.7%).

A comparison of the results showed that there was more consistency in the inability of students to correctly classify some careers over others. For example, both boys and girls had the most difficulty correctly classifying the following careers as needing Math or Science in high school: graphic artist, counselor, journalist, conservationist. The majority of both sexes correctly classified mechanical engineers and teachers.

There were statistically significant differences in the percentage of students that correctly classified pharmacist, oral hygienist, nutritionist, teacher, lawyer, medical technician, veterinarian, and child and youth worker. In all cases, more girls than boys correctly classified the career as needing Math or Science in high school. Nearly 71% of girls classified pharmacist as requiring Math or Science compared with 50.4% of boys ($Z = -3.75$, $p = 0.01$). Close to 79% of girls correctly classified teachers compared with 63.4% of the boys ($Z = -3.08$, $p = 0.01$). Nearly 73% of girls correctly classified veterinarians compared with 43.8% of boys ($Z = -5.43$, $p = 0.01$). Nutritionist and oral hygienist were both correctly classified by 53.4% of girls. By comparison, 34.8% of boys correctly classified oral hygienists and 36.8% correctly classified nutritionist. The differences were statistically significant for both nutritionist ($Z = 2.97$, $p = 0.01$) and oral hygienist ($Z = 3.39$, $p = 0.01$). Lawyers were correctly classified by 58.2% of girls and 38.6% of boys ($Z = -3.57$, $p = 0.01$). Teachers were correctly classified by 78.8% of girls and 63.4% of boys ($Z = -3.08$, $p = 0.01$). Medical technicians were correctly classified by 65.9% of girls and 49.6% of boys ($Z = -2.91$, $p = 0.01$). Child and youth workers were correctly classified by 47.8% of girls and 28.8% of boys ($Z = -3.55$, $p = 0.01$). There were no statistically significant differences between public school girls and boys for remaining 16 careers. The results are summarized in Table 8.

For students in the Math Profile group, the top five correctly classified careers were teacher (81.9%), pharmacist (74.8%), veterinarian (72.9%), geologist (68.8%), and mechanical engineer (68.1%). The five careers with the fewest correct classifications included forensic analyst (40.3%), graphic artist (34.1%), counselor (32.8%), conservationist (27.2%), and journalist (23%). Students in the Science camp group had the following careers in the top five correctly classified: teacher (83.8%), veterinarian (80.6%), computer hardware engineer (78.8%), pharmacist (77.6%), geologist (72.7%). The five careers with the fewest correct classifications included land surveyor (45.6%), ophthalmologist (43.8%), child and youth worker (37.3%), conservationist (31.3%), and journalist (18.2%). Comparisons between the Math Profile group and the Science camp group revealed that both groups more successfully classified veterinarian, teacher, pharmacist, and geologist, while less successfully classifying journalist. The only statistically significant difference between career classifications was for computer hardware engineer. This career was correctly classified by more girls from the Science camp group (78.8%) than the Math Profile group (63.3%) ($Z = -2.39$, $p = 0.05$). The results show that there is little difference between these two groups regarding their knowledge of the requirement for studying Math or Science in high school for various careers. The results appear in Table 9.

Table 8 Comparison of career requirements for Math/Science in high school public school group—girls versus boys. The number of respondents and percentage of respondents are shown for correct responses that the career requires Math and/or Science. Asterisk (*) indicates differences in percentages are statistically significant

Career	Boys	Girls	Significance test Z-value, p value
(1) Geologist	79 (57.7%)	109 (62.3%)	Not statistically significant
(2) Oil industry engineer	70 (48.6%)	95 (52.5%)	Not statistically significant
(3) Pharmacist*	70 (50.4%)	126 (70.8%)	$Z = -0.375$, $p = 0.01$
(4) Oral hygienist*	49 (34.8%)	95 (53.4%)	$Z = -0.3.39$, $p = 0.01$
(5) Landscaper	74 (51.0%)	87 (50.6%)	Not statistically significant
(6) Forensic analyst	62 (44.6%)	62 (36.5%)	Not statistically significant
(7) Behavioural psychologist	55 (39.0%)	76 (45.1%)	Not statistically significant
(8) Computer hardware engineer	83 (58.0%)	112 (62.9%)	Not statistically significant
(9) Nutritionist*	50 (36.8%)	94 (53.4%)	$Z = -0.297$, $p = 0.01$
(10) Architect	72 (51.1%)	201 (58.6%)	Not statistically significant
(11) Physiotherapist	57 (41.0%)	89 (50.6%)	Not statistically significant
(12) Graphic artist	43 (30.1%)	63 (35.6%)	Not statistically significant
(13) Conservationist	35 (25.9%)	43 (24.7%)	Not statistically significant
(14) Mechanical engineer	93 (65.5%)	114 (64.0%)	Not statistically significant
(15) Land surveyor	57 (41.0%)	86 (48.9%)	Not statistically significant
(16) Teacher*	90 (63.4%)	145 (78.8%)	$Z = -3.08$, $p = 0.01$
(17) Lawyer*	54 (38.6%)	107 (58.2%)	$Z = -3.57$, $p = 0.01$
(18) Journalist	32 (22.9%)	44 (24.6%)	Not statistically significant
(19) Counselor	36 (27.5%)	60 (35.1%)	Not statistically significant
(20) Human resource manager	45 (33.3%)	69 (39.0%)	Not statistically significant
(21) Medical technician*	67 (49.6%)	116 (65.9%)	$Z = -2.91$, $p = 0.01$
(22) Veterinarian*	60_a (43.8%)	131 (72.8%)	$Z = -5.43$, $p = 0.01$
(23) Child and youth worker*	40 (28.8%)	86 (47.8%)	$Z = -3.55$, $p = 0.01$
(24) Ophthalmologist	52 (40.9%)	67 (39.2%)	Not statistically significant

Summary of Career Knowledge and Understanding

The data above shows that boys and girls have different perceptions of what engineers do and that girls were more likely to admit that they did not know. Interestingly, more girls indicated that engineers used Math and Science whereas more boys indicated that they design things. Furthermore, our results show that girls in the Science camp group had a deeper understanding of what engineers did for a living than the Math Profile group.

Likelihood to Pursue a Career in STEM

Are there differences between middle school boys and girls in their likelihood of choosing STEM-based careers in the future (RQ5)? Students indicated how likely they were to choose a STEM career by rating their likelihood on a four-point Likert scale: (1) very likely, (2) somewhat likely, (3) somewhat unlikely, (4) very unlikely. Public school boys had an average scale rating of 2.00 (SD = 1.005) on the likelihood scale indicating that they were somewhat likely to consider a STEM career. Nearly 27% indicated that they were very likely to pursue a STEM career and 37.6% said they were somewhat likely to do so. Only 15.2% of the public school boys said they were very unlikely to consider a STEM career. Public school girls had an

Table 9 Comparison of career requirements for the Math Profile group versus Science camp. The number of respondents and percentage of respondents are shown for correct responses that the career requires Math and/or Science. Asterisk (*) indicates differences in percentages are statistically significant

Career	Public school girls	Science camp girls	Significance test Z-value, p value
(1) Geologist	95 (68.8%)	48 (72.7%)	Not statistically significant
(2) Oil industry engineer	78 (55.4%)	38 (57.6%)	Not statistically significant
(3) Pharmacist	104 (74.8%)	52 (77.6%)	Not statistically significant
(4) Oral hygienist	79 (56.4%)	43 (65.2%)	Not statistically significant
(5) Landscaper	72 (53.7%)	41 (62.1%)	Not statistically significant
(6) Forensic analyst	54 (40.3%)	34 (53.1%)	Not statistically significant
(7) Behavioural psychologist	65 (48.1%)	34 (51.5%)	Not statistically significant
(8) Computer hardware engineer*	88 (63.3%)	52 (78.8%)	$Z = -2.39$, $p = 0.05$
(9) Nutritionist	78 (56.5%)	44 (66.7%)	Not statistically significant
(10) Architect	85 (63.0%)	49 (74.2%)	Not statistically significant
(11) Physiotherapist	75 (55.1%)	36 (55.4%)	Not statistically significant
(12) Graphic artist	47 (34.1%)	31 (45.6%)	Not statistically significant
(13) Conservationist	37 (27.2%)	20 (31.3%)	Not statistically significant
(14) Mechanical engineer	94 (68.1%)	50 (75.8%)	Not statistically significant
(15) Land surveyor	73 (53.3%)	30 (45.5%)	Not statistically significant
(16) Teacher	118 (81.9%)	57 (83.8%)	Not statistically significant
(17) Lawyer	81 (56.3%)	41 (60.3%)	Not statistically significant
(18) Journalist	32 (23.0%)	10 (18.2%)	Not statistically significant
(19) Counselor	44 (32.8%)	20 (29.9%)	Not statistically significant
(20) Human resource manager	58 (42.0%)	30 (45.9%)	Not statistically significant
(21) Medical technician	58 (42.0%)	30 (46.9%)	Not statistically significant
(22) Veterinarian	102 (72.9%)	54 (80.6%)	Not statistically significant
(23) Child and youth worker	62 (44.6%)	25 (37.3%)	Not statistically significant
(24) Ophthalmologist	55 (40.7%)	28 (43.8%)	Not statistically significant

average of 2.4 on a four-point Likert scale. Over 24% indicated that they were very likely to pursue a STEM career and 34.8% said they were somewhat likely to do so. Only 23.4% of public school girls said they were unlikely to pursue a STEM career. When comparing public school girls and boys, the results showed there were no statistically significant differences in their likelihood to consider a STEM career based on gender (Table 10).

This likelihood was also explored in the Math Profile group and Science camp girls (RQ6). The Math Profile group of girls had a scale average of 2.32 (SD = 1.07) for likelihood of pursuing a STEM career. This rating would be between somewhat likely and somewhat unlikely: a neutral scale position. Over 22% of Math Profile girls were very likely to consider pursuing a STEM career and 37.6% were somewhat likely to do so. Just over 20% were not likely to do so. The vast majority of the Science camp group were prepared to seek STEM careers. Over 47% were very likely to do so and 41.4% were somewhat likely to do so. Only 2.9% of the Science camp girls were unlikely to consider pursuing a STEM career. The average scale rating for the Science camp group was 1.67 (SD = 0.76), indicating the greater interest in STEM for this sample group. Comparisons between the Math Profile and Science camp groups revealed that while both groups were inclined to consider STEM careers, those from the Science camp group were more likely to do so. Within the Math Profile group, a statistically significant difference between average scale ratings of likelihood was found for both groups of girls (Table 11). The Science camp girls were statistically more likely to pursue a STEM career than the public school girls based on average rating on the Likert scale ($t =$

Table 10 Likelihood to pursue a STEM career in public school group—girls versus boys. The numbers of respondents and percentages of respondents are shown. Total numbers of respondents are also given (boys: 171 out of 179; girls: 201 out of 207)

Response	Boys ($n = 171$)	Girls ($n = 201$)
(1) Very likely	46 (26.9%)	49 (24.4%)
(2) Somewhat likely	70 (40.9%)	70 (34.8%)
(3) Somewhat unlikely	29 (17.0%)	35 (17.4%)
(4) Very unlikely	26 (15.2%)	47 (23.4%)
Average rating ± standard deviation	2.20 ± 1.005	2.40 ± 1.096

5.208, df = 182.6, $p = 0.000$) despite equal attitudes towards Math and knowledge of STEM careers. Furthermore, while there were no significant differences between the numbers of girls from each group who said that they were somewhat likely (2) or somewhat unlikely (3) to seek a STEM career, there were statistically significant differences for very likely and very unlikely between these groups ($\chi^2 = 19.371$, df = 3, $p = 0.000$). Specifically, more girls in the Science camp cohort were very likely to pursue a STEM career and more girls in public school were very unlikely to pursue a STEM career. The results are summarized in Table 11.

In summary, our data shows that there were no statistically significant differences in their likelihood to consider a STEM career based on gender; however, our Science camp cohort of girls were more likely to be interested in pursuing a STEM-based career than our Math Profile group. The significance of this result is discussed below.

Discussion

In order to obtain contextual information from students so that we could better understand their likelihood to pursue a STEM-based career and their knowledge of careers including engineering, we asked students about attitudes towards Math. We selected Math because previous research has shown that individuals with high math capabilities were most likely to pursue STEM careers (e.g. Wang et al., 2013; Blotnicky et al., 2018). Our results show that more girls reported getting tense doing Math problems than boys, despite similar rankings of favouritism for this subject. These findings align with previous research where female students viewed Math as more difficult and felt more threatened by failure than male students (Vrugt et al., 2008) despite having similar achievement as males. Furthermore, one of the main challenges identified for

Table 11 Likelihood to pursue a STEM career for Math Profile group versus Science camp. The numbers of respondents and percentages of respondents are shown. Asterisk (*) indicates differences in average ratings are statistically significant. Total numbers of respondents are also given (public school girls: 157 out of 158; Science camp girls: 70 out of 75)

Response	Math Profile girls ($n = 157$)	Science camp girls ($n = 70$)	Significance test
(1) Very likely*	40 (22.5%)	33 (47.1%)	$\chi^2 = 19.371$, df = 3, $p = 0.000$
(2) Somewhat likely	59 (37.6%)	29 (41.4%)	
(3) Somewhat unlikely	26 (16.6%)	6 (8.6%)	
(4) Very unlikely*	32 (20.4%)	2 (2.9%)	
Total	157 (100%)	70 (100%)	
Average rating ± standard deviation*	2.32 ± 1.07	1.67 ± 0.76	$t = 5.208$, df = 182.6, $p = 0.000$

women in their pursuit of STEM-based careers is their limited sense of belonging within this sector (Dasgupta & Stout, 2014).

Next, we explored Engineering, a profession that is heavily male-dominated in Canada—only 15.2% of newly licensed engineers in Nova Scotia are female (Engineers Canada, 2017)—and well-defined (unlike a Math career). Previous research has shown that students from elementary through secondary school grades perceive engineers as males who fixed things or designed things and/or who did mechanical repairs to trains or cars (Fralick et al., 2009; Capobianco et al., 2011). Similarly, a more recent Canadian study found that a significant percentage of grade 9/10 students have unclear views about engineering and could not make informed decisions about whether to consider that career path (Compeau, 2016). None of these studies explored perceptions of engineering based on sex. Our data shows that statistically more girls than boys report that they didn't know what engineers did for a living while more boys than girls reported that engineers designed things. These findings suggest that girls have a poorer grasp of the design aspect of what engineers do for a living, at least within our general public school cohort. Overall, only about 50% of students surveyed in our study (boys, girls, and Science camp girls) could correctly indicate that a career as an oil industry engineer required high school Math/Science for entrance into the program (Tables 8 and 9). We have previously shown that students in grades 7–9 have a limited STEM career knowledge with respect to subject requirements; however, this was marginally better in grade 9 than in grade 7 (Franz-Odendaal et al., 2016; Blotnicky et al., 2018).

Most interesting was our finding that after attendance at a week-long Science camp in which the girls had the opportunity to interact with female role models in science, technology, and engineering, significantly more girls report that engineers design things and make the world a better place than a comparative cohort of girls who had similar attitudes towards Math. These findings demonstrate that the immersion in an intensive Science camp experience likely alters perspectives on STEM-based careers. This finding is supported by earlier work that hypothesized that understanding the true work of engineers will attract more females to this career (Sinkele & Mupinga, 2011; Xu, 2017).

We have previously shown that students in grades 7–9 with low Math self-efficacy have a declining interest in STEM careers (Blotnicky et al., 2018). Our current study shows that there is no difference between boys and girls in their likelihood to pursue a STEM-based degree while in grade 7. However, interestingly, the girls attending Science camp were statistically more likely to indicate their interest in pursuing a STEM-based degree than girls from the same grade who were just as adept at obtaining good marks in Math (Table 11). This is likely because it is well known that role models (together with family members and work experiences) are important influencers in the career decision-making process (e.g. Madill et al., 2004; Quimby & De Santis, 2011). Furthermore, Conner and Danielson (2016) found that engaging in authentic science, viewing female scientists as personable, the level of science preparation, and having an understanding of self-concept about science are more important factors than simply gender matching when it comes to role models. The girls in the Science camp in our dataset had the opportunity to meet informally with several female STEM role models over the five-day camp. In addition, they also had the chance to engage with meaningful hands-on science activities. The combination of role models and activities appears to have significantly impacted interest among the girls attending Science camp to pursue STEM-based careers.

Conclusions and Recommendations

Our data clearly shows that boys and girls in grade 7 from Atlantic Canada similarly rank Math as a favourite subject, demonstrating differences in their confidence in Math and differences in STEM-career understanding. These findings should be further explored to determine when and how their attitudes towards Math are shaped by the current Math curriculum, Math teachers, and Guidance Counsellors. Furthermore, we show that girls that attended a week-long Science camp had a deeper understanding of

STEM-based careers than girls who did not attend the camp but who had similar Math attitudes. This data provides direct evidence that designing Science-based camps that are meaningful to girls and that enable them to interact with female STEM professionals significantly increases their understanding of STEM-based careers and their interest in pursuing these careers in the future.

Evidence continues to mount that women's career choices including those in STEM fields are more difficult to predict than those of men (Creamer & Laughlin, 2005). Indeed, there is empirical support that there is a broad array of factors that affect self-efficacy and resiliency to continue to pursue a STEM career despite stereotype threat. There is a need to understand the way in which individuals make meaning of their experiences as we consider their sense of agency and self-efficacy (Lent et al., 2000). These factors of agency and self-efficacy depend on the way individuals appraise and respond to their experiences and the way they interpret supports, opportunities, and barriers. Our previous research has shown that students who engage more with STEM outside of school (e.g. participation in science camps, special STEM programs, or STEM competitions) are more interested in pursuing STEM-based careers in the future. Specifically, engagement in such STEM activities increased the odds of pursing a STEM career by 2.4 times (Franz-Odendaal et al., 2016).

Other research has demonstrated that girls pursue careers that are altruistic and that are people-orientated (Eccles & Wang, 2016). The work done by all STEM professionals does help society in many ways and many STEM professionals work in teams and have a creative component to their jobs, yet these aspects of STEM careers are not portrayed to girls at the critical decision-making ages in grades 6–12. Our data shows that enabling girls to interact with like-minded girls with shared interests and with local female STEM professionals impacts their interest in pursuing these careers in the future. With repeated exposure to these professionals, stereotypes within STEM can be challenged, which will reduce stereotype threat. Therefore, we suggest that Science camps should incorporate meaningful interactions with professionals currently working in STEM-based fields and should not solely be based on hands-on activities. Furthermore, these hands-on activities should be consciously presented in a manner that appeals to girls (i.e. avoiding male stereotypes, using non-gendered language, etc.). These strategies in turn will have enormous impact on the self-efficacy of girls and their attitudes towards careers that are based on Math and Science.

For Canada to narrow the current STEM gender imbalance, more effort should be made to connect professional women in these fields directly with youth. It is important that both boys and girls see more women in these fields (Lee & Lim, 2019). For girls, this exposure will improve their sense of belonging in the field as demonstrated by our data, and for boys, this exposure will likely reduce their negative attitudes (gender biases) towards working alongside women in these fields. A study that exposed fifth grade students to female scientists in their education program found improved science-related attitudes and science career awareness for females in girls and boys (Lee & Lim, 2019). Exposure to female role models for all students will ultimately improve the workplace climate for women in these fields. For this increased exposure to be successful, industry stakeholders must fully recognize this need and should encourage their highly skilled female STEM professionals to undertake these interactions with youth. They must also value the time that these women spend doing this type of work and not expect it to be done after hours or in addition to their skilled jobs. While these interactions remain a philanthropic after-work hours activity, the gender imbalance in Canada within STEM fields will remain fairly stagnant.

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Compliance with Ethical Standards

This research was approved by Mount Saint Vincent University's Research Ethics Board (File # 2011-106) and permissions were obtained from school board superintendents and parents/guardians.

Conflict of Interest The authors declare that there is no conflict of interest.

References

Agard, E. (2017). Help shape the future of STEM education in Canada. Canada 2067. Retrieved from https://canada2067.ca/en/articles/help-shape-the-future-of-stem-education-in-canada/. Accessed Dec 2019.

Ball, C., Huang, K. T., Cotten, S. R., & Rikard, R. V. (2017). Pressurizing the STEM pipeline: An expectancy-value theory analysis of youths' STEM attitudes. *Journal of Science Education and Technology*, *26*(4), 372–382.

Blotnicky, K. A., Franz-Odendaal, T., French, F., & Joy, P. (2018). A study of the correlation between STEM career knowledge, mathematics self-efficacy, career interests, and career activities on the likelihood of pursuing a STEM career among middle school students. *International Journal of STEM Education, 5*(1), 22.

Bandura, A. (1986). Self-regulatory mechanisms. In E. Cliffs (Ed.), *Social foundations of thought and action: A social cognitive theory* (pp. 335–389). NJ: Prentice Hall.

Capobianco, B. M., Diefes-dux, H. A., Mena, I., & Weller, J. (2011). What is an engineer? Implications of elementary school student conceptions for engineering education. *Journal of Engineering Education*, *100*(2), 304–328.

Chachashvili-Bolotin, S., Lissitsa, S., & Milner-Bolotin, M. (2019). STEM outcomes of second-generation immigrant students with high-skilled parental backgrounds. *International Journal of Science Education, 41*(17), 2465–2483. https://doi.org/10.1080/09500693.2019.1686549

Compeau, S. (2016). The calling of an engineer: High school students' perceptions of engineering (Dissertation). Queen's University, Kingston, Ontario, Canada

Conner, L. D. C., & Danielson, J. (2016). Scientist role models in the classroom: how important is gender matching?. *International Journal of Science Education*, *38*(15), 2414–2430.

Creamer, E. G., & Laughlin, A. (2005). Self-authorship and women's career decision making. *Journal of College Student Development*, *46*(1), 13–27.

Crozier, S. D. (1999). Women's career development in a "relational context". *International Journal for the Advancement of Counselling*, *21*(3), 231–247.

Cutumisu, M., & Bulut, O. (2017). Problem-solving attitudes and gender as predictors of academic achievement in mathematics and science for Canadian and Finnish students in the PISA 2012 Assessment. In *EdMedia+ Innovate Learning* (pp. 728-738). Association for the Advancement of Computing in Education (AACE).

Dabney, K. P., Tai, R. H., Almarode, J. T., Miller-Friedmann, J. L., Sonnert, G., Sadler, P. M., & Hazari, Z. (2012). Out-of-school time science activities and their association with career interest in STEM. *International Journal of Science Education, Part B*, *2*(1), 63–79.

Damaske, S. (2011). *For the family? How class and gender shape women's work*. New York: Oxford University Press.

Dardenne, B., Dumont, M., & Bollier, T. (2007). Insidious dangers of benevolent sexism: Consequences for women's performance. *Journal of Personality and Social Psychology*, *93(5),* 764–779.

Dasgupta, N., & Stout, J. G. (2014). Girls and women in science, technology, engineering, and mathematics: STEMing the tide and broadening participation in STEM careers. *Policy Insights from the Behavioral and Brain Sciences*, *1*(1), 21–29. https://doi.org/10.1177/2372732214549471

Davies, P. G., Spencer, S. J., Quinn, D. M., & Gerhardstein, R. (2002). Consuming images: How television commercials that elicit stereotype threat can restrain women academically and professionally. *Personality and Social Psychology Bulletin*, *28*(12), 1615–1628.

DeCoito, I. (2016). STEM education in Canada: A knowledge synthesis. *Canadian Journal of Science, Mathematics and Technology Education*, *16*(2), 114–128.

Eccles, J. S. (1994). Understanding women's educational and occupational choices: Applying the Eccles et al. model of achievement-related choices. *Psychology of Women Quarterly*, *18*(4), 585–609.

Eccles, J. S., & Wang, M.-T. (2016). What motivates females and males to pursue careers in mathematics and science? *International Journal of Behavioral Development*, *40*(2), 100–106. https://doi.org/10.1177/0165025415616201

Engineers Canada. (2017). *30 by 30*. Retrieved from https://engineerscanada.ca/diversity/women-in-engineering/30-by-30

Fouad, N. A., & Smith, P. L. (1996). A test of a social cognitive model for middle school students: Math and science. *Journal of Counseling Psychology, 43*(3), 338.

Fralick, B., Kearn, J., Thompson, S., & Lyons, J. (2009). How middle schoolers draw engineers and scientists. *Journal of Science Education and Technology*, *18*(1), 60–73.

Franz-Odendaal, T. A., Blotnicky, K., French, F., & Joy, P. (2016). Experiences and perceptions of STEM subjects, careers, and engagement in STEM activities among middle school students in the maritime provinces. *Canadian Journal of Science, Mathematics and Technology Education, 16*(2), 153–168.

Frome, P. M., Alfeld, C. J., Eccles, J. S., & Barber, B. L. (2006). Why don't they want a male-dominated job? An investigation of young women who changed their occupational aspirations. *Educational Research and Evaluation*, *12*(4), 359–372.

Heilbronner, N. N. (2009). *Pathways in STEM: Factors affecting the retention and attrition of talented men and women from the STEM pipeline*. University of Connecticut.

Jaremus, F., Gore, J., Fray, L., & Prieto-Rodriguez, E. (2019). Senior secondary student participation in STEM: Beyond national statistics. *Mathematics Education Research Journal*, *31*(2), 151–173.

Lee, D. G., & Lim, H. (2019). The effects of career education using female scientists role models on elementary students' perceptions of science related career [abstract]. *Journal of Korean Elementary Science Education*, *38*(4), 510–521.

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior*, *45*(1), 79–122.

Lent, R. W., Brown, S. D., & Hackett, G. (2000). Contextual supports and barriers to career choice: A social cognitive analysis. *Journal of Counseling Psychology*, *47*(1), 36.

Lent, R.W., Brown, S. D., & Hackett, G. (2002). Career development from a social cognitive perspective. In D. Brown & L. Brook (Eds.), *Career choice and development* (pp. 373–422). San Francisco, CA: Jossey Bass.

Madill, H. M., Ciccocioppo, A. L., Stewin, L. L., Armour, M. A., & Montgomerie, T. C. (2004). The potential to develop a career in science: Young women's issues and their implications for careers guidance initiatives. *International Journal for the Advancement of Counselling*, *26*(1), 1–19.

Maltese, A. V. & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education*, *95*(5), 877–907.

Mangu, D. M., Lee, A. R., Middleton, J. A., & Nelson, J. K. (2015). Motivational factors predicting STEM and engineering career intentions for high school students. In *Frontiers in Education Conference* (FIE), 2015. 32614 2015. IEEE (pp. 1–8). IEEE. Retrieved from http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=7344065

Masnick, A., Valenti, S., Cox, B., & Osman, C. (2010). A multidimensional scaling analysis of students' attitudes about science careers. *International Journal of Science Education, 32*(5), 653–667.

Modi, K., Schoenberg, J., & Salmond, K. (2012). Generation STEM: What girls say about science, technology, engineering, and math. A Report from the Girl Scout Research Institute. New York, NY: Girl Scouts of the USA.

Murphy, C., & Beggs, J. (2003). Children's perceptions of school science. *School Science Review*, *84,* 109–116.

Murphy, S., MacDonald, A., Wang, C. A., & Danaia, L. (2019). Towards an understanding of STEM engagement: A review of the literature on motivation and academic emotions. *Canadian Journal of Science, Mathematics and Technology Education*, *19*(3), 304–320.

Nguyen, H. H. D., & Ryan, A. M. (2008). Does stereotype threat affect test performance of minorities and women? A meta-analysis of experimental evidence. *Journal of Applied Psychology*, *93*(6), 1314.

Nugent, G., Barker, B., Welch, G., Grandgenett, N., Wu, C., & Nelson, C. (2015). A model of factors contributing to STEM learning and career orientation. *International Journal of Science Education*, *37*(7), 1067–1088.

Palmer, T. A., Burke, P. F., & Aubusson, P. (2017). Why school students choose and reject science: a study of the factors that students consider when selecting subjects. *International Journal of Science Education, 39*(6), 645–662.

Quimby, J.L. & De Santis, A.M. (2011). The influence of role models on women's career choice. *The Career Development Quarterly*, *54*(4), 297–306.

Sahin, A., Ayar, M. C., & Adiguzel, T. (2014). STEM related after-school program activities and associated outcomes on student learning educational sciences. *Educational Sciences: Theory and Practice*, *14*(1), 309–322.

Schumacher, M. M., Stansbury, K. N., Johnson, M. N., Floyd, S. R., Reid, C. E., Noland, M. P., & Leukefeld, C. G. (2009). The young women in science program: a five-year follow-up of an intervention to change science attitudes, academic behavior, and career aspirations. *Journal of Women and Minorities in Science and Engineering*, *15*(4), 303–321.

Schuster, C., & Martiny, S. E. (2017). Not feeling good in STEM: Effects of stereotype activation and anticipated affect on women's career aspirations. *Sex Roles*, *76*(1-2), 40–55.

Sekaquaptewa, D., & Thompson, M. (2003). Solo status, stereotype threat, and performance expectancies: Their effects on women's performance. *Journal of Experimental Social Psychology*, *39*(1), 68–74.

Schuster C., Martiny SE, and Schmader T. (2015). Distracted by the unthought – suppression and reappraisal of mind wandering under stereotype threat. *PlosOne 10(3)*, e0122207, https://doi.org/10.1371/journal.pone.0122207

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.

Sjaastad, J. (2012). Sources of inspiration: The role of significant persons in young people's choice of science in higher education. *International Journal of Science Education*, *34*(10), 1615–1636.

van Aalderen-Smeets, S. I., & van der Molen, J. H. W. (2018). Modeling the relation between students' implicit beliefs about their abilities and their educational STEM choices. *International journal of technology and design education*, *28*(1), 1–27.

VanLeuvan, P. (2004). Young women's science/mathematics career goals from seventh grade to high school graduation. *The Journal of Educational Research*, *97*(5), 248–268.

Vrugt A. Oort FJ, Waardenburg L. (2008). Motivation of men and women in mathematics and language. *International Journal of Psychology, 44*(5), 351–359.

Xu, Y.J. (2017). Attrition of women in STEM: examining job/major congruence in the career choices of college graduates. *Journal of Career Development, 44*(1). https://doi.org/10.1177/0894845316633787

Wang, M. T., Eccles, J. S., & Kenny, S. (2013). Not lack of ability but more choice: Individual and gender differences in choice of careers in science, technology, engineering, and mathematics. *Psychological Science, 24*(5), 770–775.

Wells, B. H., Sanchez, H. A., & Attridge, J. M. (2007). Modeling student interest in science, technology, engineering and mathematics. In *2007 IEEE Meeting the Growing Demand for Engineers and Their Educators 2010-2020 International Summit* (Vol. 50, pp. 1-17). IEEE.

Zhang, L., & Barnett, M. (2015). How high school students envision their STEM career pathways. *Cultural Studies of Science Education, 10*(3), 637–656.