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Culture, Tourism and the Centre for Education Statistics

Ability in mathematics and science at age 15 and program choice in university: differences by gender

by Darcy Hango

Tourism and Centre for Education Statistics Division

Main Building, Room 2001, Ottawa, K1A 0T6
Telephone: 1-800-307-3382 Fax: 1-613-951-1333

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.	not available for any reference period
..	not available for a specific reference period
...	not applicable
0	true zero or a value rounded to zero
0^s	value rounded to 0 (zero) where there is a meaningful distinction between true zero and the value that was rounded
^{p}	preliminary
^{r}	revised
x	suppressed to meet the confidentiality requirements of the *Statistics Act*
^{E}	use with caution
F	too unreliable to be published
*	significantly different from reference category ($p < 0.05$)

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Acronyms

The following acronyms are used in this publication:

CEGEP	Collège d'enseignement général et professionnel
CIP	Classification of Instructional Programs
CV	Coefficient of variation
NELS	National Educational Longitudinal Study
NHS	National Household Survey
OECD	Organisation for Economic Co-operation and Development
PISA	Programme for International Student Assessment
PSE	Post-secondary education
PSIS	Postsecondary Student Information System
SAT	Scholastic Aptitude Test
STEM	Science, technology, engineering, mathematics and computer science
YITS	Youth in Transition Survey

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Abstract

Past research has revealed that young women are more likely to enter postsecondary programs that have lower returns in the labour market, such as the arts, humanities and social sciences. Young men, conversely, tend to enrol in and graduate from programs in science, technology, engineering and mathematics (STEM), which generally have greater labour market returns. Factors such as academic interests, achievement test scores, and high-school marks can affect later university program choice. Using the linked Youth in Transition Survey (YITS)–Programme for International Student Assessment (PISA) data, the current paper examines the relationship between mathematics and science test scores at age 15 and first program choice in university, with a focus on differences in ability in mathematics and science by gender. Generally speaking, the results reveal that the intersection of gender and ability does matter; even young women of *high* mathematical ability are less likely to enter STEM fields than young men of similar or even *lesser* mathematical ability. This implies that something other than pure ability is affecting young women's likelihood of entering STEM programs in university.

1. Introduction

A marked gender gap in educational attainment exists today, with women attending postsecondary (PSE) education in greater numbers than men. However, this has not always been the case; in the past, men enrolled in university at higher rates than women (Clark 2000) but, today, because of higher female high-school graduation rates and greater participation in university, females have increased their overall level of education relative to men. Turcotte (2011), for example, cites figures from the Labour Force Survey showing that, in 1990, men and women, aged 25 to 34, graduated from university in about equal proportions (at 15%); however, by 2012, the rate for women had increased to 37% while, for men, the proportion increased but only to 26%. A similar reversal in the gender gap has also been found elsewhere (see Buchmann, DiPrete and McDaniel 2008; Goldin, Katz, and Kuziemko 2006; Jacob 2002).

Yet, despite all the gains in women's level of education relative to men, for the most part, they still lag behind men in terms of earnings. Williams (2010) finds, for instance, that the average total income of men has been consistently higher than that of their female counterparts for the past several decades. In 2008, for example, men earned over $45,000 on average, while women earned about $30,000 on average. Among young men and women under the age of 34, the gender gap in income was smaller than for older age groups, but a significant income gap of about $10,000 prevailed in 2008. Other Canadian research echoes these findings. Hango (2010), for instance, found that among a recent cohort of Canadian young adults, females earned less, and were less likely to be employed than their male counterparts several years after leaving full-time education. There is other evidence to suggest, however, that the gender gap in pay and inequality may be narrowing (Cooke-Reynolds and Zukewich 2004; Drolet 2011).

Part of the explanation for the continued earnings gap may lie in the postsecondary program choices made by young Canadian adults.[1] Not all university programs lead to similar labour market outcomes (Finnie 2001; Frenette and Coulombe 2007; Gerber and Cheung 2008; Giles and Drewes 2001; Walters 2004). This continued economic discrepancy across program types leads to poorer female economic outcomes, because women have traditionally entered postsecondary programs that have lower returns in the labour market (Bobbit-Zeher 2007; Christie and Shannon 2001; Davies and Guppy 1997; Gerber and Cheung 2008; Frenette and Coulombe 2007; McMullen, Gilmore and Petit 2010; OECD 2011; Turner and Bowen 1999). McMullen and her colleagues (2010) found that, in 2007, over 80% of all university graduates in the health professions were women, while between 60% and 70% of the social and behavioural sciences and humanities graduates were women. In contrast, 30% or less of the mathematics, computer and information science, or engineering graduates, were women. These figures are also echoed at the doctoral level in Canada (Desjardins and King 2011) and in the United States (England, Allison, Li, Mark, Thompson, Budig and Sun 2007). Christie and Shannon (2001), meanwhile, used the 1986 and 1991 Canadian Censuses, and found that gender differences in industry and occupation of employment as well as field of study are the largest contributors to the explained portion of the gender gap in earnings; much more so than differences in level of educational attainment. In other words, women's earnings are typically lower than men's based on their choice of university major, not on the level of degree obtained.[2]

Over time, the gender gap by field of study has narrowed, but continues with women and men still choosing traditional university fields of study (Andres and Adamuti-Trache 2007; Frenette and Coulombe 2007; Zarifa 2012). For example, England et al. (2007) found that, in the United States, even though female graduation rates in traditionally male fields, such as engineering and mathematics, have increased since the early 1970s, they are still substantially lower than male graduation rates in these disciplines. Recent Canadian data, meanwhile, from the 2011 National Household Survey (NHS) found that women held a higher share of university degrees among younger university STEM graduates than among older ones, but men still held the majority of university STEM degrees—young women aged 25 to 34 represented 39.1% of university STEM degrees in that age group (Ferguson and Zhao 2013).

Part of the explanation for gender differences in university program choice may lie in academic interests and ability in high school. Past research has found, not surprisingly, that youth with strong mathematical and/or science abilities are more likely to go into university programs where mathematical and science skills are essential (Trusty 2002; Trusty, Robinson, Plata and Ng 2000). However, a great deal of past work has found that girls score lower than boys on tests related to mathematical skills, yet do better on tests related

1. Other explanations related to family formation and the presence of children affecting female labour force participation are also important and have been well studied, but remain outside the scope of the current paper and will not be examined further (see Phipps, Burton, and Lethbridge 2001; Waldfogel 1998; Zhang 2009).

2. Interestingly this same finding was observed much earlier by Wannell (1990), who discovered that differences in field of study were much more important than differences in level of education in explaining the wage gap.

to reading (Bussière, Knighton and Pennock 2007; Downey and Vogt Yuan 2005; Niederle and Vesterlund 2010; OECD 2009; OECD 2012). Meanwhile, in terms of science knowledge, not much overall difference between boys and girls has been found (Bussière, Knighton and Pennock 2007; OECD 2009; OECD 2012). However, is it lower ability in mathematics related disciplines that drives girls away from choosing university programs where these skills are necessary, or is it that girls are simply not as interested in mathematics as boys, or perhaps have less confidence in their abilities than boys?

This paper will examine first university program choice of young men and women, by paying particular attention to their mathematical and science ability at age 15. This paper cannot isolate all potential characteristics that may or may not affect program choice in university; however, it can help uncover the link between gender, mathematical and science ability and program choice, while controlling for a wide range of factors.

Section two summarizes recent literature that focuses on the link between mathematical and science ability and program choice, with a focus on gender differences. Section three describes the data and methodology used for the analysis, followed by the concluding section, which presents the results and analytical discussion.

2. Literature review

The purpose of the current paper is to examine the link between gender, mathematics and science test scores at age 15, and first program choice in university. Therefore, this literature review will concentrate on those relatively few studies in Canada and elsewhere that address this relationship. The lack of available data on this topic may explain the paucity of research in this area in Canada. Before the Youth in Transition Survey (YITS) and the Programme for International Student Assessment (PISA) were linked in 2000, no suitable data sources comprising measures of both mathematical and science ability (other than marks), in adolescence, existed that could be attributed to a student's program choice in university.

Many studies (e.g., OECD 2010) have used mathematics or science marks as measures of ability. While these studies are quite closely linked to ability measured via test scores, they may not be true objective indicators of mathematical or science ability. This is because of issues related to student behaviour and performance and other school factors, such as the teacher–student relationship, and curricula (Cornwell, Mustard, and Van Parys 2011). Moreover, important gender differences have been found in terms of performance, as measured by marks or by achievement tests, with girls generally having been found to do better than boys with respect to marks, but not achievement tests (Duckworth and Seligman 2006).

While this paper cannot address why the performance of boys and girls differs in mathematics/science marks and achievement tests, it is important to highlight some of the earlier literature in this area. For example, one potential explanation for the gender discrepancy in marks is that girls are typically more self-disciplined than boys with regard to school work and, as a result, girls may work harder in school (and exhibit better classroom behaviour), resulting in higher marks (Downey and Vogt Yuan 2005). Conversely, however, girls typically exhibit lower mathematics test scores than boys. This work finds that the reasons for the discrepancy range from the type of activities boys and girls do outside the classroom —with boys more involved in activities that promote quantitative skills and girls more involved in activities that promote verbal/reading skills (Downey and Vogt Yuan 2005) — to more biological explanations. These purport that boys outperform girls on most measures of visuospatial abilities (which are more tightly connected with mathematical and science ability) (see Halpern, Benbow, Geary, Gur, Shibley Hyde, and Gernsbacher, 2007 for a review). These issues are complex and beyond the scope of this paper; thus, the focus is placed, instead, on literature looking at university program choice and the intersection between gender and ability in mathematics/science.

The National Educational Longitudinal Study (NELS) from the United States (years encompassing 1988 to 1994) has been used as a source of data for examining the link between academic ability in high school and program choice in university. For example, Goyette and Mullen (2006) used a combined academic proficiency measure that integrates mathematical and reading academic proficiency tests administered to students in grade 12. Major field of study was split into two categories: arts and science (includes humanities, science, mathematics, and social sciences) and vocational (includes business, education, engineering, pre-professional such as law, medicine, architecture and also other occupationally oriented majors such as agriculture, communications, design, protective services).[3] Goyette and Mullen found that their measure of academic proficiency is positively related to entering arts and science programs versus vocational programs. They do not analyze the relationship between academic proficiency and university program choice separately by gender.

3. Differences in categorization between Goyette and Mullen and the current study make comparisons difficult; the categories completely overlap and are not mutually exclusive.

Correll (2001) used the 1988 to 1994 waves of NELS, and found that mathematics test scores in grade 8 led to a higher likelihood of a student choosing a major in university that requires 'quantitative' skills and knowledge (such as engineering). This effect remained after controlling on verbal test scores, mathematics and English grades, as well as mathematical and verbal ability self-assessments and calculus enrolment in high school. However, while Correll did not assess the interaction effect of mathematics test scores by gender, her study is important because it illustrates the importance of self-assessment. For example, she found that males are more likely than females, with the same mathematics marks and test scores, to perceive that they are competent in mathematics. Thus, her

> "results suggest that those who persist on a mathematical career path may not even be the best qualified for careers requiring mathematical proficiency. In other words, boys do not pursue mathematical activities at a higher rate than girls do because they are better at mathematics. They do so, at least partially, because they *think* they are better." (p. 1724).

Trusty (2002) echoed this finding on the importance of self-assessment when he found that mathematical self-perception reduced the predictive ability of science and mathematical ability, with those who perceive themselves to be good at mathematics more likely to choose a mathematics/science program.

Additional evidence from the NELS (Trusty, Robinson, Plata and Ng 2000) found that men choose programs such as engineering, medicine and sciences more often, whereas women choose programs such as education, nursing and ethnic studies more often. However, ability in grade eight operated differently by gender. For example, the interaction of mathematics and reading test scores and gender showed that across all postsecondary majors, mathematical ability in grade eight had a stronger influence on men's program choices, while reading ability had a stronger influence on women's choices.

In subsequent work using the NELS, Trusty (2002) looked at the factors determining the choice of science/mathematics majors versus all others. He observed that, in models for men that included science and mathematics test scores, the science score was positive and significantly related to a person choosing a science/mathematics major. The influence of mathematical ability was not significant in these models, but was in those that did not include science, which suggests a relatively high degree of overlap between mathematics and science measures. Moreover, course-taking behaviour appeared to matter. For example, for women, mathematics scores appeared to be more important than science scores, but the inclusion of variables related to course-taking behaviour (i.e., especially important was whether the respondent took a mathematics-related course such as geometry, trigonometry and calculus in high school) completely removed the positive effect of mathematics test scores on postsecondary program choice. For men, the effect of science test scores on choosing a mathematics or science major remained after including course-taking behaviour.

Using a more selective American sample of entrance test scores, from 12 academically selective colleges and universities from the 1951, 1976, and 1989 entering cohorts, Turner and Bowen (1999), showed that men with high mathematics Scholastic Aptitude Test (SAT) scores were more likely to enter the fields of mathematics/physics and engineering than their female counterparts with similar mathematics SAT scores. In contrast, females with high mathematics SAT scores were more likely to enter the humanities, other social sciences, and bio-life sciences than their male counterparts with high mathematics SAT scores. However, Turner and Bowen found that achievement scores were only one, small factor that helped predict gender differences in program choice at university. In fact, factors related to differences in preferences and labour market expectations were even more important in explaining the gender gap in program choice.[4] Similarly, Ware and Lee (1988) discovered that, in high school, different things influence men's and women's decisions on program choice. For example, women who went into non-scientific fields placed the greatest importance on how their education decisions would affect future family and personal life.[5]

The research that examines the impact of mathematical/science ability, measured via test scores instead of marks, on postsecondary program choice is scant internationally, and is even less common in Canada. In fact, in Canada there appears to be no single study that actually uses mathematics or science test scores to estimate a youth's first program type in university. The two closest studies at the national level also use the YITS-PISA file (see Finnie and Childs 2010; and OECD 2010). However, neither of these studies uses mathematics or science PISA test scores, but rather use the PISA reading test score in combination with reading, mathematics, and science marks.

4. They suggest that women may prefer fields where skills do not deteriorate or become obsolete as quickly. They may be more likely to stay away from fields related to highly technical subjects such as computer science, so that time away from work to raise a family is not as harmful for one's career.

5. Using a birth cohort in the United Kingdom from 1958, Van de Werfhorst, Sullivan and Cheung (2003) also found that a large gender discrepancy in program choice (particularly into the sciences) cannot be fully explained via mathematical ability at age 11: other factors such as social class, family background and cultural capital in the home also remain very important.

Finnie and Childs (2010) found that high PISA reading scores increase the probability of entering a STEM (science, technology, engineering and mathematics) field in university, but the effect is somewhat greater for males than it is for females. Conversely, the PISA reading score appears to be related more strongly to non-STEM participation for females than males. For both sexes, mathematics and science marks in high school also indicate a greater propensity for entering STEM programs in university. The OECD (2010) results also generally support these findings, but split out university fields of study beyond the STEM/non-STEM dichotomy. For instance, greater reading proficiency measured via the PISA reading scores, at age 15, indicate a greater likelihood of a student choosing a pure sciences or life science program versus one in the human sciences, arts, or communication fields. Marks in mathematics or science achieve the same effect, while marks in reading show the opposite; namely, that youth with higher reading marks are more likely to choose the human sciences, arts or communication fields versus the pure or life sciences. The link between high marks in high school and choosing science programs in university is further exemplified in recent work from Burrow, Dooley, Wright and DeClou (2012). Using administrative data from Ontario, they found that high school graduates with the highest marks (the top 5%) are most likely to enrol in science courses. For example, in 2008, approximately half of these high achievers chose science programs in university, while less than 20% chose arts programs.

This review provided an overview of recent research that studied the relationship between relatively objective measures of mathematical and science ability and the eventual choice of program in university. Across different countries, examples were found that used different mathematics/science tests, as well as different categorizations of subject area in university. Even though the type of mathematical and science ability measures as well as the university program categorization varied across studies, their findings showed a great deal of consistency in: there is a link between mathematics or science test scores (and also reading scores) and university program choice. Youth with stronger mathematical and science ability are more likely to choose programs where these skills are essential (such as science and engineering). However, these studies also illustrate that many other factors are also important. Most notable are mathematics or science marks, as well as subjective self-assessments of one’s mathematical skills. In fact, a recent OECD (2012) study suggests that “gender disparities in subjects chosen appear to be related more to student attitudes (such as motivation and interest) towards a particular subject rather than to ability and performance at school” (p. 104).

3. Data and Methods

3.1 Data – Youth in Transition Survey (YITS), Cohort A

This report uses the linked Youth in Transition Survey (YITS)-Programme for International Student Assessment (PISA) data, which contains data from the Canadian component of the PISA survey from 2000 when youth were aged 15, and longitudinal YITS data to age 25 (Cycle 6). Using these data allows for the linking of characteristics during adolescence with educational outcomes in young adulthood.[6]

Data from Cycle 1 to Cycle 6 (age 25) were used to take into account as many youth as possible with first PSE programs. Other work (see Finnie and Childs 2010 and OECD 2010), which measured program choice only up to age 21 (or Cycle 4), benefitted from a larger sample size; however, the disadvantage is a potential loss of information. For example, Finnie and Childs (2010) found that by age 21, 25% of youth had not yet started PSE. In the current sample extending to age 25, that figure drops to below 20% (see Table 1A). Moreover, given the current interest in male and female differences, measuring to only age 21 may lead to the unnecessary exclusion of males who eventually go on to PSE beyond age 21. Finnie and Childs (2010) found that 31% of males and 19% of females had not started PSE by age 21: a substantial gap, which decreases to about 24% for males and 12% for females by age 25 in the current sample (analysis not shown). Thus, by including up to Cycle 6, this paper is likely including more males who go into university than in some alternate work.

3.2 Outcome: First University Program

The first university program is measured from Cycle 2 (age 17) through to Cycle 6, when the youth reached age 25. In this study, only university-bound youth are included because of the inherent difficulty in comparing programs across institution type. The non-university-bound youth are interesting and very important, but are left to future work.[7]

6. See especially OECD (2010) for a description of these linked PISA-YITS data as well as their usefulness.

7. The non-university bound population made up approximately 35% of the total sample, while the university bound made up 46% and the group who had not attended any PSE by December 2005 made up 19%.

Using YITS's program rosters from Cycles 2 through 6, a respondent's first university program was determined using Classification of Instructional Program (CIP) codes for the first main field of study or specialization. While a person's first program type may not be their final program upon graduation (if they graduate), first program type does indicate a person's initial interests out of high school. Switching of programs does occur for some youth during their time in university; however, some past work has found that the majority of youths' first programs are those they remain in throughout five years of university. Finnie and Childs (2010) found, for example, that 38% of students that were not in science, technology, engineering and mathematics (non-STEM) fields either switched programs or left university by their fifth year in university, while the proportion who left one of these STEM programs was much less at 24%.

In this study, the program-type measure re-categorized the 13 primary groupings in CIP (Classification of Instructional Programs) 2000 into five categories. The five new categories, informed from some past literature (see Montmarquette, Cannings, and Mahseredjian 2002) are as follows: (1) Social Sciences (includes arts, education, humanities, social sciences, and law), (2) Business/Management/Public Administration, (3) Science/Mathematics/Computer Science, Engineering and Agriculture, (4) Health, Parks, Recreation and Fitness, and (5) Other. For sake of parsimony, the five category titles are shortened to: (1) Social Sciences, (2) Business, (3) STEM, (4) Health, and (5) Other. (See Appendix Table 1 for a description of the re-categorization).[8]

Table 1A shows the distribution of the programs for all youth including those who never went to university by age 25 (including those who went to some other type of PSE) and for just the university-bound population across both the mathematics and science samples.[9]

Social science programs are the most common first programs in university. Next most common are the STEM programs, followed by Business, Health, and Other categories. Notably, around 20% of young adults had not started a first PSE program by December 2009 when they were aged 25.

Among young women, the most common first university programs are in the Social Sciences: 50% of females choose these types of programs as their first at university (Table 1B). This is much higher than the proportion of males going into the Social Sciences, at only 32%. For young men, the most common first university programs are in STEM fields, at 44%. In contrast, only 20% of females' first university programs are in STEM fields. Meanwhile, the proportion of both men and women who enter Business programs is basically identical at 14%. Women in turn appear to be significantly more likely than men to have a first university program in the field of Health.[10]

Table 1.A
First program type

	Mathematics subsample		Science subsample	
	Total	University bound	Total	University bound
	percentage			
STEM	24.4	29.9	23.6	27.8
Social sciences	28.9	41.6	28.8	44.0
Business	13.0	14.3	13.6	15.2
Health	8.9	10.0	7.5	8.6
Other	6.4	4.1	6.3	4.5
Not started PSE by December 2009 (C6)	18.5	...	20.2	...
Weighted sample size	337,121	155,271	336,377	145,966

... not applicable

Note: STEM includes science, technology, engineering, mathematics and computer science.

Source: Sources: Statistics Canada and Human Resources and Skills Development Canada, Youth in Transition Survey (YITS); Organisation for Economic Co-operation and Development, Programme for International Student Assessment (PISA), PISA/YITS Reading Cohort, 2000 to 2010.

8. For a list of the constituent CIP series and subseries associated with the CIP primary groupings, refer to Statistics Canada (2005), pages 7–9.

9. Estimates are very similar (two percentage points or less separate them) across the two subsamples so, unless otherwise specified, results are discussed relative to the mathematics subsample.

10. These trends using YITS Cohort A are also in line with statistics from the Post-Secondary Student Information System (PSIS) except that since 2004, in PSIS, the most common university program for men is the Social Sciences, followed by STEM. Comparisons between PSIS and those data presented in Table 1B are difficult though, because the current study uses the 'first' university program whereas PSIS provides data on university programs reported in the past year. Also, the current report uses a cohort of youth aged 15, in 2000, that entered university for the first time prior to their 25th birthday in 2010, while the estimates from PSIS are based on 18- to 24- year-olds in each year, from 1992 to 2009. Nonetheless, the comparison between YITS-Cohort A and PSIS is interesting, because using PSIS allows for a broader perspective of university program trends in Canada over time. The PSIS results are available upon request.

Table 1.B
First program type for university bound students, by gender

	Mathematics subsample		Science subsample	
	Female	Male	Female	Male
	percentage			
STEM	20.4	43.7***	20.2	37.9***
Social sciences	50.2	31.6***	51.9	33.4***
Business	13.7	13.9	13.5	17.0
Health	12.3	5.5***	11.2	5.4***
Other	3.4	5.4*	3.2	6.3**
Weighted sample size	73,567	58,783	68,961	58,243

* $p < 0.1$
** $p < 0.05$
*** $p < 0.01$ indicates significance level of male/female differences

Note: STEM includes science, technology, engineering, mathematics and computer science.

Source: Statistics Canada and Human Resources and Skills Development Canada, Youth in Transition Survey (YITS); Organisation for Economic Co-operation and Development, Programme for International Student Assessment (PISA), PISA/YITS Reading Cohort, 2000 to 2010.

3.3 Mathematics and Science PISA Scores at Age 15

In the 2000 survey when the youth were aged 15, reading skill was the main focus and so only a subsample of randomly chosen respondents responded to a much smaller number of mathematics and science items than the entire sample that was assessed for reading literacy (OECD 2010; Statistics Canada 2004). In total, 32 mathematics questions and 35 science questions were included in the PISA 2000 assessments. Nonetheless, the mathematics and science scales in PISA were developed to measure mathematical and science literacy of 15 year olds, and through the pairing with the longitudinal aspect of YITS the relationship between mathematical and science literacy at age 15 can be examined with numerous outcomes into young adulthood in Canada.

Mathematical literacy is used in the current context to “indicate the ability to put mathematical knowledge and skills to functional use rather than just mastering them within a school curriculum”. Meanwhile, science literacy is defined as “the capacity to use scientific knowledge, to identify questions, and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity” (Bussière, Cartwright, Crocker, Ma, Oderkirk and Zhang 2001: 86).

This study uses average levels of mathematics and science test scores from Cycle 1 when the youth were age 15. Proficiency levels in mathematics and science were also created and used to form a measure tapping into high levels of mathematical and science ability: youth defined as having ‘high’ mathematical or science ability are in the 4th proficiency level or higher.[11] In general, youth at higher mathematical and science proficiency levels are better able to integrate and use mathematics and science concepts. Their reflection and insight into concepts as well as mathematical and science problem solving skills are stronger than youth at lower levels.

3.4 Control Variables

Several variables are included to take into account of factors that may affect the decision to enter a particular program in university. These controls therefore are less affiliated with ‘access’ to PSE, instead, access is taken as a given because the sample under consideration has started a program at university prior to age 25.[12]

11. Mathematics and science proficiency levels were not officially derived in 2000 because, in that year, only proficiency levels for reading were derived since it was the main focus. Instead, in this paper, proficiency-level cut points for mathematics are measured from 2003 (see Bussière, Cartwright, Knighton, and
Rogers 2004), while proficiency-level cut points for science are from 2006 (see Bussière et al. 2007). These two years (2003 and 2006) were the closest available to the 2000 mathematics and science assessments.
12. Approximately 46% of the sample went into university, while 35% went into some other type of PSE, and 19% had not started any PSE by age 25..

Control variables are grouped into three main categories:

1. *Factors related to student achievement and educational interests in high school* (measured at the age of 15 unless otherwise specified) — includes marks in either mathematics or science, an index of self-rated mathematical ability,[13] reading ability measured via the PISA reading tests, grade level when the PISA tests were administered, frequency of science lab usage, and an index measuring sense of control/mastery.

2. *Demographic Characteristics* include gender, province of residence at age 15, whether the respondent lived in a rural area at age 15, and whether the respondent and the parents were born in Canada.

3. *Parental/family influence* –Several familial and/or parental factors are included: parental education, the degree to which parents know their child's teacher, and two factors that measure the parent–child relationship, namely, the frequency that a parent and teen talk about the teen's future career and education, as well as the frequency of discussions of current political and social issues between parents and teens.[14]

Four of the covariates at the student level are of particular interest: marks in mathematics or science, self-rated mathematical ability, the frequency of science-lab usage, and reading ability. Marks, which are closely linked to the objective PISA measures, measure the degree of potential difficulty youth have with either mathematics or science (at least the difficulty as measured through mathematics/science course-taking), while self-rated mathematical ability and frequency of science-lab usage potentially measure one's interest and degree of confidence in the subject. However, marks may not be accurately measuring one's ability but instead may be confounded by a myriad of factors including self-discipline, one's ability to better navigate the education system in high school, and teacher perception (Cornwell et. al 2011). Meanwhile, self-rated aptitude in a subject can be confounded by gender, because girls may not rate their aptitude in a particular subject as high as it is in reality, whereas boys often have the tendency to exaggerate their abilities (Cech, Rubineau, Silbey, and Seron 2011; Correll 2001).

Thus, achievement test scores, such as the PISA scores, may be the preferred option to measure aptitude, because it may offer a truer measure of one's' ability in mathematics and science, and may not be as affected by issues such as self-discipline, aptitude inflation/deflation, or differential treatment in the school system based on gender. Nonetheless, each of these factors is important to include because they could potentially alter the relationship between objective test scores and choice of university program, and could also operate differently for young men and young women. Finally, reading ability is included to help measure students' overall academic ability beyond math and science aptitude, and it is an important indicator predicting program choice in its own right (see see Finnie and Childs 2010; and OECD 2010).

3.5 Method

Three research questions are asked in this report. First, which programs are students with high mathematical and high science abilities choosing when they first enter university? Second, does gender matter? That is, do males and females of equal mathematical and science ability choose similar programs in university? Third, is the relationship between gender, mathematical/science ability and program choice affected by other factors? The analysis will include descriptive and multivariate methods using multinomial logistic regression.

The analysis will proceed as follows: First, average levels of mathematics/science PISA scores are compared across first university program for the total university-bound sample, and also separately by gender (Table 2). Second, the intersection of gender and levels of mathematical/science (high vs. low) ability is compared with first university program (Table 3). Third, the relationship between mathematical/science ability and gender, predicting first university program choice, is assessed through a series of multivariate multinomial regression models. The first model, the bivariate model, includes only the mathematical/science ability by gender measure.

13. Self-rated mathematical ability was from Cycle 2 (age 17). It was not measured in Cycle 1.

14. With regard to parental factors, parental occupation is also a potential factor in choice of major in university (see Leppel, Williams, and Waldauer 2001). However, using these same data, OECD (2010) found no significant link between parental occupation and university program choice. As a result, the decision was made to not include it in this analysis. Parental education was retained; however, because it has been found to figure more prominently in university program choice (OECD 2010; Zarifa 2012).

The second model includes all controls, except for mathematics/science marks and self-assessed mathematical ability, while the third model (the full model) adds in these latter two measures (Table 4 and 5).[15] Multinomial logistical regression is useful for the current analysis, since it allows for multiple categories in the dependent variable without any real hierarchy, such as multiple program types (other work examining program choice has used this same technique — see Finnie and Childs 2010; Leppel et. al 2001; OECD 2010; Zarifa 2012).[16]

The analysis is restricted to the university-destined youth only; the sample under consideration does not include those whose first PSE program is in a non-university setting and also those who do not go on to a PSE program before the age of 25.[17] The choice was made to consider only university-bound youth because of comparability challenges between programs at the university and non-university levels. For example, engineering programs are offered at both colleges and universities but can be quite different, with the former being oriented more toward practical job skills. Furthermore, in multinomial models, the comparison between university program choice (STEM for example) and not going on to PSE is much less interesting or relevant than the comparison between STEM and another type of university program.[18] In all analyses, the appropriate survey weights are used, as well as the corresponding bootstrap weights. Stata's (Version 11) specialized survey procedures are used for all analyses.

4. Results

4.1 Descriptive

Table 2 presents the means of math and science scores at age 15 by first university program taken as well as by gender. The first thing to note is that, on average, males have significantly higher math scores than females, 589 vs. 569 (significantly different at .01 level) while, in terms of science scores, males have a higher average score but, in this case, it is not statistically different from females. This is not entirely surprising as earlier work has found similar results (Bussière et al. 2007).

In terms of first university program type, significant gender differences in mathematics PISA scores are observed for the social sciences and business programs. In contrast, men who enter STEM, health or other programs had higher average mathematics scores at age 15, but the difference with average female scores was not statistically significant.

For both males and females, however, average mathematics scores are highest for those who enter STEM programs; the same is also true when examining average science scores. Thus, for both males and females, higher mathematics/science scores at age 15 translate into a greater chance of a first university program being in STEM fields. However, the absence of a statistically significant gender difference across male and female averages suggests that male and female mathematics/science scores appear to operate quite similarly in affecting whether or not the first university program is in a STEM field.

The lack of significant gender differences for STEM programs might be a result of examining average levels of mathematical/science ability, which may not capture enough of the distributional differences between men and women. Table 3 presents the proportion of youth entering each type of university program by different levels of mathematical/science ability and gender. High mathematical/science ability is defined as the 4th proficiency level or higher, while lower ability is defined as the 3rd proficiency level or lower.

15. The analysis was done this way to isolate the effects of mathematics/science marks and self-assessed mathematical ability. These two are both correlated, more than other covariates, with mathematics/science PISA scores and also in some subsequent analyses were shown to be robust predictors of university program choice.

16. Only results from models ran with the interaction between mathematics/science score and gender are presented. Models were estimated with main effects for mathematics/science scores and gender, and are available upon request. This supplemental research showed that high mathematics/science scores led to a greater chance of entering STEM fields; however, this effect was removed after the inclusion of gender and other important controls. The main effect for gender indicated that females are much less likely to enter STEM fields than others.

17. In some additional analyses (not shown), which included the non-university-bound as well as those youth who had not started any PSE prior to age 25, the basic relationship between mathematical/science ability and gender and university program choice did not substantially change. The results are available upon request.

18. Other work also deals with these different postsecondary populations separately. See Boudarbat and Montmarquette (2009) and Boudarbat (2008).

Table 2
Mean of mathematics and science PISA scores by first program type in university, by gender

	Mathematics			Science		
	Total	Female	Male	Total	Female	Male
	means					
Total	**577.8**	**569.3**	**588.5*****	**580.2**	**578.8**	**581.8**
STEM	593.4	587.5	596.7	598.0	599.9	596.8
Social sciences	571.8	565.3	584.7**	578.8	579.2	578.0
Business	567.8	555.4	583.2*	562.3	551.5	572.5
Health	571.9	570.3	576.6	575.1	572.8	581.0
Other	570.4	572.2	569.1	551.9	576.7	536.9*
Weighted sample size	132,350	73,567	58,783	127,204	68,961	58,243

* p < 0.1
** p < 0.05
*** p < 0.01 indicates significance level of male/female differences

Note: STEM includes science, technology, engineering, mathematics and computer science.

Source: Statistics Canada and Human Resources and Skills Development Canada, Youth in Transition Survey (YITS); Organisation for Economic Co-operation and Development, Programme for International Student Assessment (PISA), PISA/YITS Reading Cohort, 2000 to 2010.

Table 3
First university program choice of YITS-PISA respondents who attended university, by category of PISA scores and gender

	STEM	Social Sciences	Business	Health	Other
	percentage				
Total mathematics PISA score by gender	**30.8**	**42.0**	**13.8**	**9.3**	**4.3**
High-Female	23.2	48.3	12.6	12.4	3.6
High-Male	45.7	31.3	13.3	5.1	4.7 E
Low-Female	15.3	53.9	15.8	12.2	2.9 E
Low-Male	38.5	32.2	15.4	F	F
Total science PISA score by gender	**28.3**	**43.4**	**15.1**	**8.5**	**4.7**
High-Female	23.8	52.3	10.1	10.8	2.9 E
High-Male	42.5	32.1	16.0	5.5	4.0
Low-Female	14.1	51.2	19.1	11.9	3.7 E
Low-Male	30.1	35.8	18.6	5.2	10.4 E

E use with caution, refers to a CV > 25 and < 33
F too unreliable to be published, refers to a CV > 33

Note: High PISA score is defined as 4th proficiency level and above. Low PISA score is defined as 3rd proficiency level or below. STEM includes science, technology, engineering, mathematics and computer science.

Source: Statistics Canada and Human Resources and Skills Development Canada, Youth in Transition Survey (YITS); Organisation for Economic Co-operation and Development, Programme for International Student Assessment (PISA), PISA/YITS Reading Cohort, 2000 to 2010.

Table 3 shows that the most common first university programs for females, regardless of mathematical or science ability, are the social sciences, followed by STEM programs, business, health, and finally all other programs. For example, around 50% of women, regardless of their mathematical/science ability, choose the social sciences. Interestingly, women with lower mathematical and science skills, while also more likely to choose social science programs, however, choose STEM programs in much lower proportions than their female counterparts who are strong in mathematics or science (about 15% vs. 23%). Thus, among young women there appears to be a relatively strong link between mathematical/science ability at age 15 and university fields of study that require substantive science and mathematics backgrounds (the STEM fields) compared with those that do not.

Conversely, among young men, the most common first university programs, regardless of mathematical or science ability, are in the STEM fields, with the exception of males of lower science ability who have a larger proportion who go into the social sciences. Similar to women, men also go into the social sciences in similar proportions (slightly more than 30%), regardless of mathematical/science ability. However, like their female counterparts of lower mathematical and science ability, men of lower mathematical and science ability go into STEM programs much less frequently than men of higher mathematical and science ability. The difference is about 7 percentage points (45.7-38.5) in the case of mathematics, and even greater at 12 percentage points (42.5-30.1) for science ability. Thus, as with women, men also appear to have a relatively strong link between mathematical/science ability at age 15 and choosing STEM fields; these within gender differences across ability do not extend to other disciplines in the same magnitude.

These descriptive results suggest that, as in Table 1B, young women are most likely to choose the social sciences as their first university program, and this does not change at high or low levels of mathematical or science ability. In other words, the most popular first university program for young women, regardless of mathematical/science ability, is in the social sciences. In contrast, for young men, the most popular programs are in the STEM fields, except for males of lower science ability, who are most likely to choose social science programs. Finally, there is some indication that youth, regardless of gender, with strong mathematical/science skills are more likely to choose STEM programs than their counterparts with lower skills. The gap is somewhat greater for science than for mathematics. These relationships will be examined further in the following section, using multivariate techniques that take other important covariates into account.

4.2 Multinomial Logistic Regression

Table 4 presents the estimates from three different specifications of multinomial logistic regression models on both the mathematics and science subsamples. The first model is the bivariate case, which only includes mathematical/science ability by gender. The second model includes the mathematics/science by gender variable, as well as a wide range of covariates (discussed earlier) known to be either related to mathematical/science ability and/or program choice. The only two covariates that are not included in Model 2 are mathematics/science marks and self-assessed mathematical ability. These remaining two variables are considered in Model 3. Table 5 presents the results from all control variables from Model 3 (the full model). In Tables 4 and 5, the results have been transformed from multinomial logits to average marginal effects for ease of interpretation. They can be interpreted as the effect of a one-unit change in any given explanatory variable on the probability of choosing each of the university programs. Four categories of mathematical/science ability by gender are specified: female-high PISA, female-low PISA, male-high PISA, and male-low PISA. In all analyses, young women with high PISA mathematics/science scores are taken as the reference category.

Table 4
Average marginal effects of mathematical/science ability at age 15 by gender, based on three different multinomial logit models predicting university program choice

	Mathematics PISA models					Science PISA models				
	STEM	Social Sciences	Business	Health	Other	STEM	Social Sciences	Business	Health	Other
	average marginal effects									
Model 1: Bivariate, PISA score by gender only										
PISA score by gender (ref: high-female)										
High-Male	0.224 ***	-0.170 ***	0.007	-0.073 ***	0.011	0.187 ***	-0.203 ***	0.059 **	-0.053 ***	0.010
Low-Female	-0.080 ***	0.056	0.032	-0.001	-0.007	-0.097 ***	-0.011	0.090 ***	0.011	0.008
Low-Male	0.153 ***	-0.161 ***	0.029	-0.057 **	0.036	0.062	-0.166 ***	0.085 ***	-0.056 ***	0.075 ***
Model 2: Bivariate, plus all variables except for mathematics/science marks and self-assessed mathematical ability										
PISA score by gender (ref: high-female)										
High-Male	0.217 ***	-0.156 ***	0.007	-0.077 ***	0.009	0.168 ***	-0.194 ***	0.064 **	-0.050 ***	0.012
Low-Female	-0.073 **	0.093 *	-0.002	-0.009	-0.010	-0.070 *	-0.021	0.063 *	0.023	0.005
Low-Male	0.145 ***	-0.117 **	-0.006	-0.057	0.034	0.097 *	-0.177 ***	0.047	-0.044 *	0.077 ***
Model 3: Full model, bivariate, plus demographic and parental controls, and mathematics/science marks and self-assessed mathematical ability										
PISA score by gender (ref: high-female)										
High-Male	0.178 ***	-0.126 ***	0.004	-0.074 ***	0.018	0.113 ***	-0.147 ***	0.063 **	-0.051 ***	0.022 *
Low-Female	-0.010	0.012	0.007	0.006	-0.015	-0.040	-0.060	0.072 *	0.026	0.001
Low-Male	0.194 ***	-0.159 ***	-0.010	-0.053	0.028	0.094 *	-0.170 ***	0.043	-0.047 **	0.080 **
Weighted sample size	132,350					127,204				

* p < 0.1
** p < 0.05
*** p < 0.01 indicates significant difference from the reference (ref) category
Note: STEM includes science, technology, engineering, mathematics and computer science.
Source: Statistics Canada and Human Resources and Skills Development Canada, Youth in Transition Survey (YITS); Organisation for Economic Co-operation and Development, Programme for International Student Assessment (PISA), PISA/YITS Reading Cohort, 2000 to 2010.

4.2.1 The effect of mathematical/science ability and gender on program choice

The bivariate results at the top of Table 4 replicate the proportions given in Table 3; thus, the focus here will be on how the coefficients change across models given the addition of control variables. Two relationships from the bivariate results, and how they change with the inclusion of control variables, will be assessed: (1) Does the gender difference remain in choosing STEM, and social science programs? (2) Are males and females of high mathematical/science ability, as measured through PISA scores, more likely to go on to STEM programs than their lower ability counterparts, even after controlling for factors such as mathematics/science marks and self-assessed mathematical ability?[19]

First, it was observed that males, regardless of mathematical ability, have a higher probability of entering STEM programs than females. For instance, in the bivariate case, males of high mathematical ability have a 22.4% higher probability of going into a STEM field than females of equally high mathematical ability (the 0.224 effect indicated in Table 4). Also, even males of lower mathematical ability have a 15.3% higher probability of entering a STEM program than females who have high mathematical ability. This male advantage in entering STEM programs holds in Model 2, and even in Model 3, once mathematics marks and self-assessed mathematical ability are added. In the full model, males of high mathematical ability have a 17.8% higher probability of choosing a STEM program in university than females of equally high ability, while males of lower mathematical ability have a 19.4% greater probability.[20]

19. The results related to STEM and social sciences are focused on, since these are the two most common first university programs of choice.
20. In some additional analyses, which stepped in mathematics marks and self-assessed mathematical ability individually into Model 3, self-assessed ability had a larger impact on reducing the difference between males and females of higher mathematics ability choosing STEM programs. These results are available upon request.

The story for science, gender and choosing STEM is more or less the same, except that males with lower science ability do not have a higher probability of entering STEM programs than women of high science ability. For instance, in model 3, males of high science ability have an 11.3% higher probability of entering STEM programs than females of an equally high level, while the value for males of low science ability is only just significant at the 10% level. Part of the discrepancy between males and females of high science ability choosing STEM is explained through the covariates because in the bivariate case, males of high ability had an 18.7% higher probability of entering STEM, which was reduced about 7 percentage points once science marks and self-assessed mathematical ability were included.[21]

Females, conversely, regardless of mathematical or science ability, are more likely to choose social science programs. For instance, according to Model 3, males of high mathematical ability have a 12.6% lower probability of entering social science programs than females of equally high mathematical ability. For males of lower mathematical ability the probability (15.9%) of entering social science programs is even lower when compared to females of high mathematical ability.[22] A similar effect is observed in the science results.

Thus, it appears that mathematical and science ability have little effect on explaining gender differences in program choice, at least when considering STEM and social science programs. Granted, females of high mathematical ability have a higher probability of entering STEM programs than their counterparts with lower mathematical and science ability, but their higher mathematical ability is not sufficient to erase the difference in STEM attendance from males with even lower mathematical ability. Likely, something other than ability (as measured through the PISA assessments) is driving the difference in the decision of males and females to choose one of these two major programs in university. It is also something other than mathematics/science marks, self-assessed mathematical ability, and numerous other factors related to student achievement and educational interests at age 15.[23]

The second issue to be examined involves the question of whether males and females of high mathematical/ science ability (as measured through PISA scores) are more likely to go into STEM programs than their lower ability counterparts (same gender), after controlling for factors such as mathematics/science marks and self-assessed mathematical ability. For women, results from Table 4 show that marks and self-assessed mathematical ability may have more of an impact on program choice than ability as measured via PISA scores. For instance, in the bivariate case, women with lower mathematics PISA scores had an 8% lower probability of entering a STEM program than females with high mathematics PISA scores. In Model 2, this difference, while still significant, was reduced to 7.3% and, by Model 3, the difference in choosing STEM based on mathematics PISA scores was completely removed for women. Thus for women, mathematical ability, as measured through PISA scores, does little to explain differences in STEM attendance in university, once mathematics marks and self-assessed mathematical ability are taken into account.[24] A very similar finding was discovered for women with respect to science PISA scores and choosing STEM programs: science marks, as well as one's perceptions of his or her abilities in mathematics, explained away the difference between young women of higher and lower science ability.

For men, there is no real difference in the probability of entering a STEM program based on mathematics PISA scores. In the bivariate model, the difference between these two groups is only significant at the 10% level. In the other two models, there is no difference. In the science results, in the bivariate case, males with high science PISA scores have a 12% ($p < .01$) higher probability of entering a STEM program than their lower ability counterparts. However, this difference is completely removed in model 2 once most of the control variables are included.[25]

4.2.2 The effect of marks and self-assessed mathematical ability on program choice

Table 5 presents the marginal effects for the covariates used in Model 3, the full model. Given that models are not estimated separately by gender, these marginal effects cannot reveal anything about gender differences in program attendance. This would require additional analyses with males and females separated. Nonetheless, it is informative to present the results for mathematics and science marks and self-assessed mathematical ability, given the importance that these two measures have with regard to gender, PISA scores, and university program choice.

21. In some additional analyses, self-assessed mathematical ability was more influential than science marks in reducing the male–female difference in STEM attendance. These results are available upon request.

22. Also, while not shown explicitly in Table 4, females of low mathematical ability have an even greater probability of entering social science programs than males, regardless of their mathematical ability. This is known because of the positive marginal effect associated with females of lower mathematical ability (0.012).

23. Finnie and Childs (2010) also found that mathematics and science marks did little to explain the gender gap in STEM attendance.

24. This paper was mainly focused on the intersection between PISA scores and gender and so interaction terms between marks and gender, and self-assessed mathematical ability and gender were not introduced into the models. These relationships are interesting but are left for future work.

25. It is unclear which of the covariates presented in Model 2 explained away the difference between males with high versus lower PISA science scores; further analysis would be needed to isolate each of the individual factors.

Table 5
Average marginal effects of the controls used in Model 3 (full model) from Table 4: Based on multinomial logit models predicting university program choice

	Mathematics PISA models					Science PISA models				
	STEM	Social Sciences	Business	Health	Other	STEM	Social Sciences	Business	Health	Other
	average marginal effects									
Demographic characteristics										
Province of high school (ref: Quebec)										
Atlantic	-0.017	0.026	0.018	-0.005	-0.022	0.035	0.058**	-0.034*	0.007	-0.066***
Ontario	-0.003	0.018	0.030	0.011	-0.055***	0.017	0.066**	0.022	-0.027	-0.077***
West	0.002	-0.025	0.055**	0.011	-0.041***	0.076***	0.000	0.006	-0.007	-0.075***
Youth and parents born in Canada (ref: not)	-0.043*	0.060**	-0.031*	0.000	0.013	-0.037*	0.035	-0.016	0.005	0.014
Rural area at age 15 (ref: population centre)	0.074**	-0.027	-0.075***	0.034**	-0.005	0.049*	-0.007	-0.062**	0.026	-0.006
Parental/Family influence										
Parental education (ref: University)										
High school or less	-0.024	-0.145***	0.043	0.093***	0.033*	-0.042*	-0.038	0.040	0.014	0.027*
Other postsecondary education	0.003	-0.061**	0.016	0.052***	-0.011	-0.0303	-0.039*	0.026	0.026*	0.017
How well parents know one or more of child's teachers (range: 1-4)	-0.031**	0.056***	-0.011	-0.007	-0.008*	-0.022**	0.031**	-0.016*	0.018*	-0.012**
Frequency that parents and child talk about future career/education (range: 1-5)	0.013	0.002	-0.007	0.001	-0.009*	0.011	-0.018	0.005	-0.006	0.007
Frequency that parents and child talk about current political/social issues (range: 1-5)	-0.005	0.002	0.009	-0.011**	0.005	0.002	0.004	-0.004	0.004	-0.006*
Factors related to student achievement and educational interests in high school[1]										
Mark in last mathematics/science course (ref: 80% to 89%)										
59% or less	-0.087**	0.068	0.029	-0.054**	0.043*	-0.0533	0.110	-0.040	-0.009	-0.007
60% to 69%	-0.109***	0.141***	-0.003	-0.045**	0.017	-0.076**	0.046	0.021	0.009	0.001
70% to 79%	-0.068***	0.045*	0.011	-0.009	0.020*	-0.047*	0.065*	-0.033	0.001	0.015
90% to 100%	0.067**	-0.059**	-0.016	-0.015	0.024**	0.094***	-0.030	-0.035	-0.014	-0.015
Self-rated mathematical ability, age 17 (range: 1-5)	0.097***	-0.100***	0.013	0.004	-0.015***	0.103***	-0.113***	0.017*	0.011**	-0.020***
How often use science labs (range: 1-5)	0.006	-0.008	0.002	-0.004	0.004	0.014*	-0.009	-0.004	0.001	-0.001
Reading ability (PISA proficiency levels, ref: level 3)										
Level 2 or less	0.077	-0.010	-0.013	-0.044	-0.009	0.010	-0.040	0.030	-0.021	0.021
Level 4 or 5	-0.006	0.076*	-0.045	-0.009	-0.015	-0.017	0.047	-0.037	0.006	0.002
Grade 10 (ref: grade 9)	0.119***	-0.057	-0.077**	0.009	0.006	0.023	-0.033	-0.026	0.000	0.036
Sense of control/mastery index (range: 1-4)	0.007	0.001	-0.051***	0.029**	0.014	0.041*	-0.057**	-0.008	0.025**	-0.001
Weighted sample size			132,350					127,204		

* p < 0.1
** p < 0.05
*** p < 0.01 indicates significant difference from reference (ref) category
1. At age 15 unless otherwise specified.
Note: STEM includes science, technology, engineering, mathematics and computer science.
Source: Statistics Canada and Human Resources and Skills Development Canada, Youth in Transition Survey (YITS); Organisation for Economic Co-operation and Development, Programme for International Student Assessment (PISA), PISA/YITS Reading Cohort, 2000 to 2010.

In terms of marks, the highest marks (average marks of 90% to 100%) are associated with a 6.7% and a 9.4% greater probability (than average marks of 80% to 89%) of entering a STEM field, for mathematics and science marks respectively. Conversely, individuals who had average marks below 80% are significantly less likely to enter STEM fields than individuals who had average marks of 80% to 89%. Youth who had average mathematics marks of 90% to 100% were however less likely to enter the social sciences than youth who had average marks of 80% to 89%. Marks had less impact on the other fields, except that individuals with the lowest mathematics marks were significantly less likely to go into health programs than individuals with average mathematics marks of 80% to 89%. Science marks had a similar, albeit, somewhat weaker effect on program choice.

Self-rated mathematical ability (rated on a scale from poor to excellent), not surprisingly, had a very similar effect on program choice as did mathematics marks; namely that youth who rated themselves as having higher ability in mathematics were also more likely to choose STEM programs and less likely to choose social-science programs. With each increase in the scale, the probability of choosing a STEM program increased by 9.7%, while the probability of choosing a social science program decreased by 10%. Self-rated mathematical ability had a similar effect in the models using the science subsample.

5. Discussion

This paper focused on program choice in university, paying particular attention to mathematical and science ability and gender. The relationship between these three factors may have an important connection to later socioeconomic status, since past work has shown that women choose fields (such as the humanities and social sciences) that generally pay less than fields (such as STEM) typically chosen by men (Finnie 2001; Gerber and Cheung 2008). Mathematical and science ability in high school are connected to programs of study where mathematics and science are essential (such as STEM) (Trusty 2002; Trusty, Robinson, Plata and Ng 2000), thus, a goal of this paper was to connect the mathematical and science ability of young males and females with their choice of program in university. Thoughts about program choice in university often occur while youth are still in high school. Many factors go into the decision, such as influence from parents and friends, but one of the most important may be aptitude for a particular subject.

The analysis confirmed that young men more often choose to go on to STEM programs in university, while young women choose the social Sciences, arts and humanities or health-related fields. This finding resonates with past Canadian (see Christie and Shannon 2001; McMullen et al. 2010) and American literature (see Bobbit-Zeher 2007; Geber and Cheung 2008). Also expected and in line with past literature (see Trusty 2002; Trusty et al. 2000) was the finding that youth with strong mathematical and science skills more often enrol in programs that require and utilize these skills (e.g. STEM programs), and finally this analysis confirmed that there were distinct gender differences on mathematics scores in high school (males typically have higher scores), but not science test scores. This finding was discovered across Canada (see Bussière et al. 2007) and a range of other countries (see Downey and Vogt Yuan 2005; Niederle and Vesterlund 2010; OECD 2012).

New results, which used a measure combining gender with levels of mathematical and science proficiency, showed two main findings. First, males, regardless of mathematical or science ability, were more likely to go into STEM fields than young women of *high* mathematical ability. In other words, even males of lower mathematical ability go to STEM programs significantly more than females with considerably greater mathematical skills. These differences remained in models with and without other important factors such as mathematics/science marks and self-assessed mathematical ability. The finding for science ability was similar but weaker. Second, females of high mathematical/science ability are more likely to go to STEM programs than their female counterparts of lower ability. However, the difference by ability as measured through PISA scores is explained through mathematics/science marks and self-assessed mathematical ability. That is, once mathematics/science marks and one's perception of their abilities in mathematics are taken into account, mathematical/science ability no longer factors into females' choice of STEM programs in university. For men, there was no real difference in the probability of entering a STEM program based on mathematical ability. Science ability did matter initially but disappeared in the presence of other important factors. More work is needed to fully explore which factor was most influential.

This paper, through the use of objective measures of mathematical and science ability in high school, was able to illustrate that pure ability in subjects relevant for enrolling in STEM programs in university does not necessarily guarantee that the 'best' candidates enter these science and mathematics based programs. For example, the most qualified young women in terms of mathematical and science ability were less likely to enter STEM programs than young men of lower ability. More work is clearly needed to better understand why those more capable and qualified are not choosing to enter fields of study connected with higher future earnings. Some research suggests that young women may place more importance than do young men on family roles and responsibilities and personal relationships when choosing future occupations and as such may shy away from programs which they deem to run counter to those priorities (see Halpern et al. 2007; Lee 2002; OECD 2012; Turner and Bowen 1999; and Ware and Lee 1988). These issues were not analyzed in the current paper and remain an area for future research.

Appendix

Table 1
Mapping between first university program types (abbreviated titles in parentheses) used in this study and CIP 2000 Primary Groupings.

First University Program Type	CIP 2000 Primary Groupings
Social Sciences **(Social Sciences)**	• Education • Visual and Performing Arts and Communications Technologies • Humanities • Social and Behavioural Sciences and Law
Business, Management, and Public Administration **(Business)**	• Business, Management, and Public Administration
Science/Mathematics/Computer Science/Engineering **(STEM)**[1]	• Physical and Life Sciences and Technologies • Mathematics, Computer and Information Sciences • Architecture, Engineering and Related Technologies • Agriculture, Natural Resources and Conservation
Health, Parks, Recreation and Fitness **(Health)** (this is the broad group label across all PSE types however at the university level the majority are from Health)	• Health, Parks, Recreation and Fitness
Other **(Other)**	• Personal Improvement and Leisure • Personal, Protective and Transportation Services • Other

1. The analysis in this paper was mostly completed before a new Statistics Canada recommended standard on STEM definition was developed. The STEM grouping in this report is carried out at the level of primary groupings of CIP (Classification of Instructional Programs) 2000, while the recommended standard was developed using lower levels of CIP 2011. For more information on the Statistics Canada's recommended STEM groupings, please see: http://www23.statcan.gc.ca/imdb/p3VD.pl?Function=getVDPage1&TVD=139116&db=imdb&dis=2&adm=8

References

Andres, Lesley and Adamuti-Trache, Maria. (2007). "You've come a long way baby? Persistent gender inequality in university enrolment and completion in Canada, 1979-2004," *Canadian Public Policy* 33(1): 93-116.

Bobbitt-Zeher, Donna (2007). "The gender income gap and the role of education," *Sociology of Education* 80(1): 1-22.

Boudarbat, Brahim. (2008). "Field of study choice by community college students in Canada," *Economics of Education Review* 27: 79-93.

Boudarbat, Brahim and Montmarquette, Claude. (2009). "Choice of fields of study of university Canadian graduates: The role of gender and their parents' education," *Education Economics* 17(2): 185-213.

Buchmann, Claudia, DiPrete, Thomas A., and McDaniel, Anne. (2008). "Gender inequalities in education," *Annual Review of Sociology* 34: 319-337.

Burrow, J., Dooley, M., Wright, T., and DeClou, L. (2012). *A Report on the Postsecondary Decisions of High-Achieving Students in Ontario*. Toronto: Higher Education Quality Council of Ontario.

Bussière, Patrick, Cartwright, Fernando, Crocker, Robert, Ma, Xin, Oderkirk, Jillian, and Zhang, Yanhong. (2001). *Measuring Up: The Performance of Canada's Youth in Reading, Mathematics and Science: OECD PISA Study – First Results for Canadians Aged 15*. Statistics Canada, Catalogue No. 81-590-XPE, Ottawa.

Bussière, Patrick, Cartwright, Fernando, Knighton, Tamara, and Rogers, Todd. (2004). *Measuring Up: Canadian Results of the OECD PISA Study: The Performance of Canada's Youth in Mathematics, Reading, Science, and Problem Solving*. Statistics Canada, Catalogue No. 81-590-XPE, No. 2, Ottawa.

Bussière, Patrick, Knighton, Tamara, and Pennock, Dianne. (2007). *Measuring Up: Canadian Results of the OECD PISA Study: The Performance of Canada's Youth in Science, Reading and Mathematics – 2006 First Results for Canadians Aged 15*. Statistics Canada, Catalogue No. 81-590-XPE, No. 3, Ottawa.

Cech, Erin, Rubineau, Brian, Silbey, Susan, and Seron, Caroll. (2011). "Professional role confidence and gendered persistence in engineering," *American Sociological Review* 76(5): 641-666.

Christie, Pamela and Shannon, Michael. (2001). "Educational attainment and the gender wage gap: Evidence from the 1986 and 1991 Canadian censuses," *Economics of Education Review* 20: 165-180.

Clark, Warren. (2000). "100 years of education," *Canadian Social Trends* Winter: 3-7.

Cooke-Reynolds, Melissa and Zukewich, Nancy. (2004). "The feminization of work," *Canadian Social Trends* Spring: 24-29.

Cornwell, Christopher M., Mustard, David B., and Van Parys, Jessica. (2011). *Non-cognitive skills and the gender disparities in test scores and teacher assessments: Evidence from primary school*. IZA Discussion Paper, No. 5973. Bonn, Germany.

Correll, Shelley J. (2001). "Gender and the career choice process: The role of biased self-assessments," *American Journal of Sociology* 106(6): 1691-1730.

Davies, Scott and Guppy, Neil. (1997). "Fields of study, college selectivity, and student inequalities in higher education, *Social Forces* 75(4): 1415-1436.

Desjardins, Louise and King, Darren. (2011). *Expectations and Labour Market Outcomes of Doctoral Graduates from Canadian Universities*. Culture, Tourism and the Centre for Education Statistics Research Papers, Statistics Canada Catalogue Number 81-595-MIE2011089, Ottawa.

Downey, Douglas B. And Vogt Yuan, Anastasia S. (2005). "Sex differences in school performance during high school: Puzzling patterns and possible explanations," *The Sociological Quarterly* 46: 299-321.

Drolet, Marie. (2011). “Why has the gender wage gap narrowed?” *Perspectives on Labour and Income* 23 (1). Statistics Canada. Catalogue no. 75-001-X: 3-13.

Duckworth, Angela Lee and Seligman, Martin E. P. (2006). “Self-discipline gives girls the edge: Gender in self-discipline, grades and achievement test scores,” *Journal of Educational Psychology* 98(1): 198-208.

England, Paula, Allison, Paul, Li, Su, Mark, Noah, Thompson, Jennifer, Budig, Michelle J. and Sun, Han. (2007). “Why are some academic fields tipping toward female? The sex composition of U.S. fields of doctoral degree receipt, 1971-2002,” *Sociology of Education* 80(1): 23-42.

Ferguson, Sarah Jane and Zhao, John. (2013). *Education in Canada: Attainment, field of study and location of study*. 2011 National Household Survey (NHS) analytical document. Catalogue no. 99-012-X2011001. Ottawa: Statistics Canada.

Finnie, Ross. (2001). “Fields of plenty, fields of lean: The early labour market outcomes of Canadian university graduates by discipline,” *The Canadian Journal of Higher Education* 31(1): 141-176.

Finnie, Ross and Childs, Stephen. (2010). *STEM students: Who goes into science, technology, engineering, and mathematics disciplines, and what happens when they get there – Evidence from the Youth in Transition Survey*. Paper presented at the Annual Statistics Canada Socio-Economic Conference, 2010, Gatineau, Quebec.

Frenette, Marc and Coulombe, Simon. (2007). *Has Higher Education Among Young Women Substantially Reduced the Gender Gap in Employment and Earnings*? Analytical Studies Research Paper Series. Catalogue no. 11F0019m2007301. Ottawa: Statistics Canada.

Gerber, Theodore P. and Cheung, Sin Yi. (2008). “Horizontal stratification in postsecondary education: Forms, explanations, and implications,” *Annual Review of Sociology* 34: 299-318.

Giles, Philip and Drewes, Torben. (2001). “Liberal arts degrees and the labour market.” *Perspectives on Labour and Income* 13 (3). Statistics Canada. Catalogue no. 75-001-X: 27-33.

Goldin, Claudia, Katz, Lawrence F., and Kuziemko, Ilyana. (2006). “The homecoming of American college women: The reversal of the college gender gap,” *Journal of Economic Perspectives* 20(4): 133-156.

Goyette, Kimberly and Mullen, Ann L. (2006). “Who studies the arts and sciences? Social background and the choice and consequences of undergraduate field of study,” *The Journal of Higher Education* 77(3): 497-538.

Halpern, Diane F., Benbow, Camilla P., Geary, David C., Gur, Ruben C., Shibley Hyde, Janet, and Gernsbacher, Morton Ann. (2007). “The science of sex differences in science and mathematics,” *Psychological Science in the Public Interest* 8(1): 1-51.

Hango, Darcy (2010). *Labour Market Experiences of Youth After Leaving School: Exploring the Effect of Educational Pathways Over Time*. Culture, Tourism and the Centre for Education Statistics Research Papers, Statistics Canada Catalogue Number 81-595-MIE2010087, Ottawa.

Jacob, Brian A. (2002). “Where the boys aren’t: Non-cognitive skills, returns to school and the gender gap in higher education,” *Economics of Education Review* 21: 589-598.

Lee, James Daniel. (2002). “More than ability: Gender and personal relationships influence science and technology involvement,” *Sociology of Education* 75(4): 349-373.

Leppel, Karen, Williams, Mary L., and Waldauer, Charles. (2001). “The impact of parental occupation and socioeconomic status on choice of college major,” *Journal of Family and Economic Issues* 22(4): 373-394.

McMullen, Kathryn, Gilmore, Jason and Le Petit, Christel. (2010). “Women in non-traditional occupations and fields of study,” *Education Matters* 7(1). Statistics Canada Catalogue No. 81-004-x. http://www.statcan.gc.ca/pub/81-004-x/2010001/article/11151-eng.htm (accessed August 10, 2012).

Montmarquette, Claude, Cannings, Kathy, and Mahseredjian, Sophie. (2002). “How do young people choose college majors?” *Economics of Education Review* 21: 543-556.

Niederle, Muriel and Vesterlund, Lise. (2010). "Explaining the gender gap in math test scores: The role of competition," *Journal of Economic Perspectives* 24(2): 129-144.

OECD (2009). *Equally Prepared For Life? How 15 Year Old Boys and Girls Perform in School.* OECD, Paris

OECD (2010). *Pathways to Success: How Knowledge and Skills at Age 15 Shape Future Lives in Canada.* OECD, Paris.

OECD (2011), *Report on the Gender Initiative: Gender Equality in Education, Employment and Entrepreneurship 2011*, Report prepared for the Meeting of the OECD Council at Ministerial Level, Paris, 25-26 May 2011, OECD Publishing, Paris.

OECD (2012). *Closing the Gender Gap: Act Now*. OECD Publishing. http://dx.doi.org/10.1787/9789264179370-en

Phipps, Shelley, Burton, Peter, and Lethbridge, Lynn. (2001). "In and out of the labour market: Long-term income consequences of child-related interruptions to women's paid work," *Canadian Journal of Economics* 34(2): 411-429.

Statistics Canada (2004). *Youth in Transition Survey 2000: PISA/YITS Reading Cohort, Cycle 1 User Guide*. Statistics Canada, Ottawa.

Statistics Canada (2005). *Classification of Instructional Programs, Canada, 2000*. Catalogue Number 12-590-XIE. Statistics Canada, Ottawa.

Trusty, Jerry. (2002). "Effects of high school course-taking and other variables on choice of science and mathematics college majors," *Journal of Counseling and Development* 80: 464-474.

Trusty, Jerry, Robinson, Chester R., Plata, Maximo, and Ng, Kok-Mun. (2000). "Effects of gender, socioeconomic status, and early academic performance on postsecondary educational choice," *Journal of Counseling and Development* 78: 463-472.

Turcotte, Martin. (2011). "Women and education," *Women in Canada: A Gender-Based Statistical Report*. Statistics Canada. Catalogue Number 89-503-X.

Turner, Sarah E. and Bowen, William G. (1999). "Choice of major: The changing (unchanging) gender gap," *Industrial and Labor Relations Review* 52(2): 289-313.

Van De Werfhorst, Herman G., Sullivan, Alice and Cheung, Sin Yi. (2003). "Social class, ability and choice of subject in secondary and tertiary education in Britain," *British Educational Research Journal* 29(1): 41-62.

Waldfogel, Jane. (1998). "Understanding the 'family gap' in pay for women with children'" *Journal of Economic Perspectives* 12(1): 137-156.

Walters, David. (2004). "A comparison of the labour market outcomes of postsecondary graduates of various levels and fields over a four-cohort period," *Canadian Journal of Sociology* 29(1): 1-27.

Wannell, Ted. (1990). "Male-female earnings gap among recent university graduates." *Perspectives on Labour and Income* 2 (2). Statistics Canada. Catalogue no. 75-001-X.

Ware, Norma C. and Lee, Valerie E. (1988). "Sex differences in choice of college science majors," *American Educational Research Journal* 25(4): 593-614.

Williams, Cara. (2010). "Economic well-being," *Women in Canada: A Gender-Based Statistical Report*. Statistics Canada. Catalogue Number 89-503-X.

Zarifa, David. (2012). "Choosing fields in an expansionary era: Comparing two cohorts of baccalaureate degree-holders in the United States and Canada," *Research in Social Stratification and Mobility* 30: 328-351.

Zhang, Xuelin. (2009). "Earnings of women with and without children." *Perspectives on Labour and Income* 10 (3). Statistics Canada. Catalogue no. 75-001-X: 5-14.