What is the Role of Mathematics Proficiency on Academic and Labour Market Outcomes of College Students?

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Executive summary

Recent reports affirm concerns about the numeracy and math skills of Canadians, pointing to a decline in skills or performance at a level too low for what is needed for a productive labour force. Previous Canadian research indicates that math performance in high school is predictive of performance in postsecondary. Additionally, strong numeracy skills have been shown to be associated with stronger labour market outcomes including employment and earnings.

Most of these studies were conducted at a national or provincial level. They did not control for sociodemographic characteristics (such as gender, age, income, parental education) or math skills at college entry. In contrast, the current study examined the role of mathematics proficiency on the academic and labour market outcomes of students from a large Toronto college. This research has not been before done in Canada, and the approach undertaken is unique: the study tracks student-level data on math performance and course selection in in senior high school, college program selection and standardized math testing at entry, progress to college graduation, and labour market and further education outcomes post-graduation.

The current study's overall research question was: *What influence does mathematics proficiency have on academic and labour market outcomes of college students?*

The study addressed this question by investigating the following sub-questions:

- What role does high school math performance and course selection play in program choice in college, particularly in technology fields or other programs requiring math? Is there an independent effect of gender or socioeconomic status?
- What role does high school math background (grades and course selection) play in performance on standardized college math placement testing and overall academic outcomes in college?
- Do math skills at college entry predict college academic performance or overall persistence to graduation? Does language proficiency affect math performance?
- Does math proficiency affect transfer rates to university?
- Does math proficiency affect labour market outcomes such as employment rate, hourly wage, overqualification and job related to program of study?

Methodology. This study used a database containing several linked student-level data sources from within Seneca College, which enabled the tracking of individual students from the beginning of high school, through to college graduation and transition into the labour market or further education. The sample included students who entered Seneca College between 2007 and 2014 that were under 23 years of age at entry, were not enrolled in a college degree or graduate certificate program, and had completed the entering-student survey. The total sample contained 44,613 college entrants and 9,414 graduates (respondents of the Graduate Satisfaction Survey (GSS)). The study used both descriptive and regression techniques to estimate the effects of high school math achievement and math proficiency at college entry on college performance and post-graduation prospects.

Results. This report shows that students' math performance (course selection and grades) in high school strongly influences whether they select a program requiring math at college entry. Within the population of students who entered college programs requiring math, math proficiency has a major effect on

performance on college math placement testing, first-year college math grades, overall college Grade Point Average (GPA), rate of graduation and labour market outcomes.

Of the Seneca students who graduated from Ontario high schools, those who obtained a higher average in high school math and took university preparation math courses were more likely to select a college program requiring math and/or enter a technology program, to have higher scores on college math placement tests and a lower odds of placement in a college foundation math course, and to have higher first-year college math grades, higher overall college GPA, and higher graduation rates.

Higher scores on college math placement tests are associated with higher first-year math grades, overall college GPA and graduation rates. Graduates who had a higher first-year college math average were more likely to transfer to university and to be employed; if employed, this group of graduates were more likely to have a job related to their field of study and less likely to be overqualified. Math proficiency at college entry had no effect on their hourly wage.

As well, the study identified sociodemographic and other factors that interacted with program selection, math proficiency and graduate outcomes, as described below:

Gender. Male students are more likely than their female counterparts to take advanced math courses in high school, to enter a college program requiring math, and to enter a technology field even when controlling for high school background. Independent of high school background in math, males on average also achieve higher scores on college math placement tests. Yet, within programs requiring math, females generally obtain higher first-year college math grades and higher overall college GPAs, and are more likely to graduate. Among those employed, females are less likely than males to be overqualified for their job; however, they are more likely to earn a lower hourly wage.

Aspirations for university. Students who enter college with plans to go on to university are more likely to choose a program requiring math. However, among all college entrants who pursue a college program requiring math, students who aspire to later attend university generally have poorer academic outcomes.

Canadian citizenship. Seneca college students who are Canadian citizens are less likely than their non-citizen counterparts to select a program requiring math. Among Canadian citizens who do select a program requiring math obtain lower scores on college math placement tests, a lower college math average in first year, a lower overall college GPA, and a lower graduation rate compared with their non-citizen counterparts. Among Seneca graduates in the labour force, citizens are more likely than non-citizens to be employed, but less likely to have a job in their related field of study, and are more likely to be overqualified. Despite this, Canadian citizens still earn a higher hourly wage.

Neighbourhood income and parental education. Students from low income neighbourhoods and those with a university-educated parent are more likely to enter a technology field. On average, students from high income neighbourhoods perform better on college math placement tests; they obtain higher math grades in first year and a higher overall GPA, and graduate at a higher rate compared with students from low income neighbourhoods. Students who have a parent with a degree perform better on college math placement testing and generally obtain higher salaries compared with students whose parents do not have a degree, or whose parents' level of education is unknown.

Time Trends. Notable time trends were observed, even when controlling for any differences in the composition of entering students. In recent years, results on standardized math placement tests, college math averages, overall college GPA and graduation rates have all declined.

Summary: This study clearly shows the long-term repercussions of weak math proficiency on college program selection, academic performance and post-graduation outcomes. Students with weak math skills are less likely to enter college programs requiring math; they obtain lower college math and lower college grades overall, and are less likely to graduate and to obtain a job related to their program of study.

Overall, results of the current study suggest that students who obtain both higher grades in high school and take advanced high school math courses are more likely to perform better on required college math placement tests and to select college programs that require math. In turn, higher math proficiency at college entry is positively associated with better overall college performance and a higher likelihood of graduating from college, transferring to university, and finding a job post-graduation. As well, numerous sociodemographic factors — particularly gender, neighbourhood income, parental education, English-language ability, and Canadian citizenship — interact in complex ways with program selection, math proficiency and graduate outcomes, and require further research.

Introduction

There has been growing concern about the numeracy and math skills of Canadians, with several reports pointing to a decline in skills or performance at a level too low for what is needed for a productive labour force (Dion, 2014; Orpwood & Brown, 2015). Many of these concerns can be traced to patterns of math course selection at the high school level, selection of programs with a math component in postsecondary, academic performance in postsecondary, and labour market outcomes.

The role of math proficiency and gender in STEM program selection for college students has not been studied in Canada. For university programs, higher grades in high school math and PISA[1] mathematics scores at age 15 is predictive of selecting programs in science, technology, engineering, mathematics and computer science (considered STEM fields), with women less likely to select a STEM program regardless of math ability (Hango, 2013). This is evident in the gender imbalance in STEM programs in Ontario's colleges and universities[2]. In Ontario universities only 17% of females versus 35% of males graduated from STEM programs in 2014.The gender gap is even wider for graduates of Ontario colleges[3]: in 2014, only 5% of females graduated from a STEM program compared with 22% of male graduates.

A recent study on students in the Toronto District School Board who were transitioning into college or university, looked at the characteristics of students who selected STEM programs and students who chose non-STEM programs (Robson, Brown, Maier & Ranjbar, 2017). The study showed that STEM entrants were less likely than those entering non-STEM programs to have special education needs and to have similar parental education and occupation backgrounds as their non- STEM peers. However, males were far more likely than females to enter college STEM programs.

Academic success and graduation: Studies of Ontario college students[4] provide evidence of the strong effect of high school grades and course selection on first-year math outcomes: about one-third of college students obtained first-year math grades of D or less, putting them at high risk of not completing their program. Weak grades in high school math, combined with taking math courses that did not adequately prepare students for college math, accounted for much of their poor performance (College Student Achievement Project, 2015).

One issue rarely addressed is whether standardized math proficiency tests can appropriately assess students with low English-language skills. A study of students attending a Toronto college (Choi et al., 2013) showed that English-language learners performed as well as their counterparts on items that required minimal language skills, but performed significantly lower on items that required more advanced language skills.

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[1] Programme for International Student Assessment

[2] Statistics Canada's Postsecondary Student Information System via Ministry of Advanced Education and Skills Development, Open SIMS, "Postsecondary STEM Graduates in Canada".

[3] Throughout this report, the term "college" refers to Ontario's publicly funded college system consisting of 24 Colleges of Applied Arts and Technology (CAATs).

[4] These studies were a part of the "College Math Project" and the "College Student Assessment Project". For background see: http://collegemathproject.senecac.on.ca/cmp/en/pdf/FinalReport/2011/CMP_2011_Final_Report%20-%2002Apr12%20pmh.pdf & http://csap.senecacollege.ca/docs/CSAP%20Cycle%202%20final%20report%2011Jun15.pdf

Post-graduation: further education and labour market success: Strong numeracy skills are associated with stronger labour market outcomes, including employment and earnings. The 2012 survey results from the Programme for the International Assessment of Adult Competencies (PIAAC) showed that only 34% of unemployed Canadians ages 16 to 65 obtained a level 3 or higher in numeracy proficiency compared with 49% of those employed (Statistics Canada, et al., 2013). A 2015 report from the Canadian Apprenticeship Forum noted the effect of high literacy and numeracy skills on earnings, suggesting also that numeracy has an even stronger effect than literacy.

Most of these studies were conducted at a national or provincial level: they looked at skills, education level and labour market performance, or exclusively at academic performance in high school and college. However, these studies did not control for individual sociodemographic characteristics (such as gender, age, income, parental education) or math skills at college entry.

This study is unique in that it follows the influence of math proficiency on college achievement, graduation, and post-graduation outcomes; it incorporates high school math course selection and grades, standardized math testing at college entry, program selection in college, progress to graduation, and labour market and further education outcomes post-graduation.

Research questions

The study's overall research question is: *What is the role of proficiency in mathematics on academic and labour market outcomes of college students?*

Research sub-questions are as follows:

1. What role does high school math performance and course selection play in program choice in college, particularly in technology fields or other programs requiring math? Is there an independent effect of gender or socioeconomic status?
2. What role does high school math background (grades and course selection) play in performance on standardized college math placement testing and overall academic outcomes in college?
3. Do math skills at college entry predict college academic performance or overall persistence to graduation? Does language proficiency affect math performance?
4. Does math proficiency affect transfer rates to university?
5. Does math proficiency affect labour market outcomes such as employment rate, hourly wage, overqualification and job related to program of study?

Research methodology

Research Design

To investigate the effect of math skill development on college pathways, the current study used a database containing linked administrative and survey data sources from within Seneca College.[5] The longitudinal dataset enabled the tracking of each student's individual high school math performance, college program choice, foundational college math courses, overall college performance to graduation,

[5]Seneca College is one of Ontario's 24 CAATs offering a range of credentials: certificates, diplomas, degrees and graduate certificates. The majority of Seneca's program offerings are two- and three-year diplomas.

and transition into the labour market or further education. The study used both descriptive and regression techniques to better understand the relationships between math ability, choice of programs in college, foundational math college courses, academic and labour market success, and further education.

Analytic Aims

The study had three analytic aims:

1) To estimate the effect of high school math course selection and achievement on college numeracy and math proficiency at entry (as assessed by college placement scores) and college program selection.
2) To estimate the effect of college numeracy and math proficiency at entry on academic achievement (college GPA, first-year average in college math, and graduation rates).
3) To estimate placement in a foundation college math course and the effect of college math grades on graduate and labour market outcomes.

Sample Selection

For all analyses in the current study, the sample was restricted to students who had entered Seneca College between 2007 and 2014, were less than 23 years of age at college entry,[6] who were not enrolled in graduate certificate programs (2nd entry) and who had completed the entering student survey.

Analysis 1 restricted the study sample to all students who had graduated from an Ontario high school with a minimum of six grade 11 or grade 12 courses (including either a grade 11 or grade 12 math course) in the Ontario Secondary School curriculum (post-double cohort) [7].

Analysis 2 used two samples: one sample was restricted to students with an Ontario high school record (same sample as used in Analysis 1), so as to examine the effect of high school math grades on college performance (college math grades, overall college GPA, graduation). The second sample was much larger, developed to investigate the effect of college math placement scores on college performance; it consisted of all students with college math placement scores, and therefore included those with and without an Ontario high school record.

The study sample for Analysis 3 included all college graduates from programs requiring college math that graduated by 2014 and participated in the Graduate Satisfaction Survey (GSS).

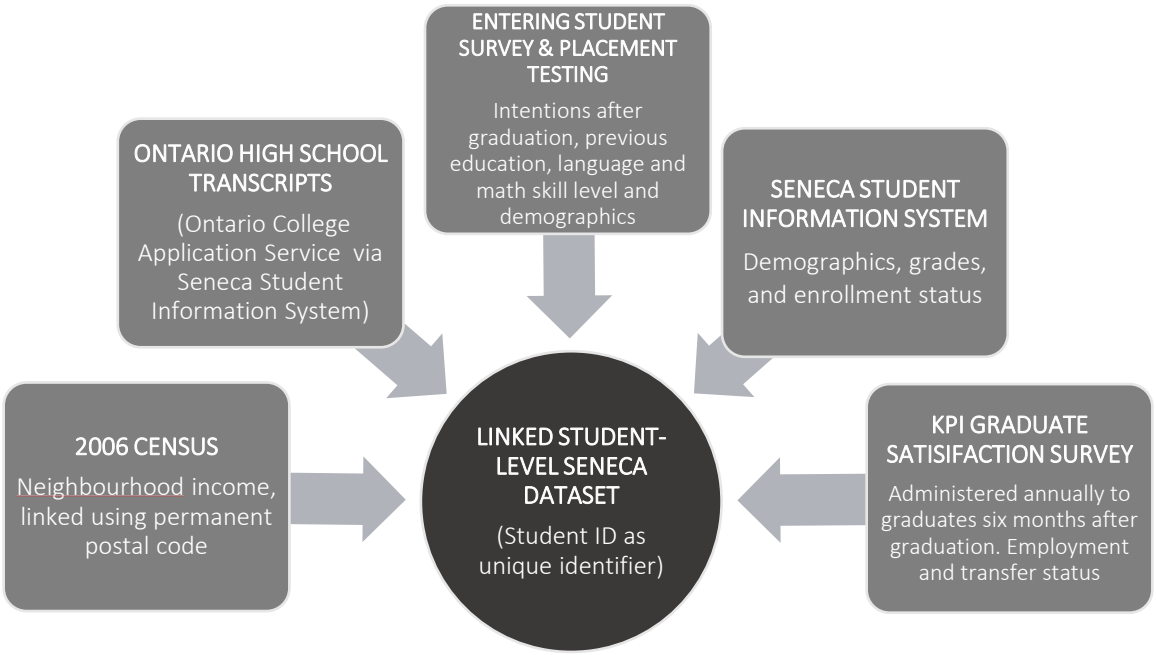
Dataset

Figure 1 depicts the linked datasets that were used for the current study, and the data contained in each. A master ID assigned to each student was used to match as many records between the datasets as possible and remove duplicates. Each student's identity was verified using a combination of the student's first name, last name, date of birth, postal code and alternative IDs previously assigned within the College's student information system. The longitudinal dataset included secondary data collected by (or on behalf of) the Ministry of Training, Colleges, and Universities (MTCU); Statistics Canada; and Ontario

[6] An age limit was chosen for two reasons: 1) to limit the share, particularly in the earlier cohort years, of students who had taken math pre-OSS; and 2) to reduce the incidence of previous university attendance.
[7] Ontario Ministry of Education and Training. *Ontario Secondary Schools, Grades 9 to 12: Program and Diploma Requirements 1999*. Retrieved from http://www.edu.gov.on.ca/eng/document/curricul/secondary/oss/oss.pdf

Colleges Application Service (OCAS). Personal information was used and stored according to Seneca's privacy protocols.[8]

Figure 1. Linked student-level dataset, Seneca College



High School Records

For every Seneca student who attended an Ontario high school, the College's student information system contains one record for every high school course taken in grades 9 to 12. The overall senior high school average was calculated from all grade 11 and 12 courses for those students who had a minimum of six grade 11 or 12 courses. The total number of failed grade 11 or 12 high school courses was calculated to better indicate whether the student struggled in high school. A variable was also generated to show whether a student took mainly university preparation courses or college preparation courses, defined as "mostly U" and "mostly C" respectively.[9] A student was classified as having taken "mostly U" high school courses if a minimum of half of the grade 11 or 12 courses taken were of a university (U) or university/college (M) type. A student was classified as having taken "mostly C" high school courses if a minimum of half of the grade 11 and 12 courses taken were of the college preparation (C) type.

The analysis for each grade 11 and 12 high school math course included the number of students who took each course, the course grade average, and the course failure rate. The complexity of math course

[8] See http://www.senecacollege.ca/registrar/FOI.html

[9] See Ontario Ministry of Education (2011). *The Ontario Curriculum Grades 9 and 12. Course descriptions and prerequisites*, http://www.edu.gov.on.ca/eng/document/curricul/secondary/descript/descri9e.pdf

pathways (number of courses and course combinations) warranted the creation of an exclusive variable to identify the most "advanced" high school math course[10] [11] taken:

1) In this hierarchy, both grade 12 university preparation & grade 12 college preparation math are considered "higher" than grade 11 university and college preparation math.
2) Within each grade level, each math university preparation course is considered "higher" than any college preparation course.
3) Grade 11 or 12 Workplace essentials (E courses) were combined and were considered the lowest level.[12]

Student Income

As an estimate of individual student household income, the student's permanent postal code was matched to household income data from the 2006 census. Using the six-digit permanent postal code in the College's student information system, each student from Ontario was assigned to a 2006 Dissemination Area (DA) using a 2011 Statistics Canada postal code conversion file (PCCF). If a student's permanent postal code was missing or invalid, the Ontario high school postal code was used. A student's neighbourhood income group was derived by splitting the DAs into income terciles of low, medium and high, based on the average pre-tax household income for Ontario households. Receiving a loan from the Ontario Student Assistance Program (OSAP) served as a marker for demonstrated financial need.

Entering Student Survey

During the mandatory placement testing, all entering Seneca students must complete a background survey, which inquired into the following variables:

- University aspirations upon entry to the College: "After graduation from my program, I plan to"
- Previous university: "The last school I attended was"
- First language: "The language I learned first was"
- Whether either parent has a university degree: "The highest level of education completed by my father (mother)/guardian is" (two separate questions for each parent).

Respondents who reported they did not know either parent's education were combined with the category of "no degree" (Steffler, McCloy, & Decock, 2016). In cases where two or more completed surveys existed, the earliest record was used to reflect a student's true entering status. The "previous university" variable is limited in scope because entering students are only asked about the last school they attended and not whether they have ever attended university or have completed a credential.

[10]Previous analysis by individual courses taken in high school and grades in college show differences in performance within, and across each grade level and course codes, indicating the complexity of the math course pathways. http://collegemathproject.senecac.on.ca/cmp/en/pdf/FinalReport/2011/CMP_2011_Final_Report%20-%2002Apr12%20pmh.pdf

[11]The Ontario Curriculum Grades 11 and 12: Mathematics, 2007. Ministry of Education. http://www.edu.gov.on.ca/eng/curriculum/secondary/math1112currb.pdf

[12]The hierarchy for analysis is as follows: grade 12 U is higher than grade 12 C; grade 12 C is higher than grade 11 U or 11 M; grade 11 U and 11 M are both higher than grade 11 C; and grade 11 C is higher than grade 11 E or 12 E. For example, if a student has taken both a grade 12 U math and a grade 12 C math, their most advanced course is grade 12 U.

Program of Entry

A student's first program of entry was considered to be the first term in which they were observed entering a full-time program approved by the MTCU. Seven program-area groupings were derived from MTCU's occupation cluster classification system and have been described previously (McCloy & Liu, 2010). The current study focused on math-based programs, and therefore program area groupings of interest included technology, business and "other". Technology programs include chemical laboratory technology, environmental technology, biotechnology, and engineering technology programs in the areas of mechanical, computer, civil, electronics, fire protection and building systems.

College Math Placement Testing

Students enrolled in Seneca's applied science and engineering technology programs[13] are required to complete the Canadian Achievement Test (CAT-3) for mathematics, level 19. Students in other programs requiring math are often required to take the computerized placement test, Accuplacer, for arithmetic and/or algebra. These placement tests aim to assess college numeracy and math proficiency among students entering a college program requiring math. Based on these test results, students may or may not be placed in a foundation math course during their first year of college.[14]

In the current study, students who had a foundation math course on their transcript were considered to have been placed in a foundation math.[15] Archived files from the Seneca-led College Student Achievement Project, and its precursor, College Math Project, were used to determine historically valid foundation and first-year math courses at Seneca.[16]

Proficiency levels for Accuplacer and CAT-3 were obtained from the product handbooks. CAT-3 scores were provided in the form of a number-correct score, converted to a linear Scale Score (for use in regression and descriptive analysis) and subsequently converted to norm-referenced scores.[17] The norm – referenced scores refer to the Canadian high school population at the end of grade 12 and are expressed as quartiles (Appendix 1). The Accuplacer proficiency levels were drawn from the ACCUPLACER Program Manual[18] (Table 1).

Table 1. Accuplacer proficiency levels for arithmetic and algebra

Arithmetic	**Score/ 120**	**Algebra**	**Score/ 120**
Below minimal skills	<31	Below minimal pre-algebra	<25
Minimal skills	31-56	Minimal pre-algebra	25-56

[13] Seneca's applied science programs include chemical laboratory technology, environmental technology, biotechnology, aviation safety and aviation operations. Engineering technology/technician programs include the areas of mechanical, computer, civil, electronics, fire protection and building systems. Students in Seneca's computer programs (with the exception of computer engineering) do not require math and therefore do not undergo math placement.

[14] See Seneca College website, http://www.senecacollege.ca/testcentre/assessment.html

[15] The dataset included a field indicating the math course the student was placed in. However, as the field was sometimes incomplete, the actual course attempted was used for the remedial definition.

[16] College Student Achievement Project, http://csap.senecacollege.ca/en/

[17] Canadian Test Centre (2001). Canadian Achievement Tests (CAT-3). Norms Book. Third Edition.

[18] The College Board (2016). ACCUPLACER Program Manual, https://secure-media.collegeboard.org/digitalServices/pdf/accuplacer/accuplacer-program-manual.pdf

Basic skills	57-89	Minimal elementary algebra	57-75
Adequate skills	90-111	Sufficient elementary algebra	76-107
Substantial skills	≥112	Substantial elementary algebra	≥108

English-language Placement Testing

Most entering students at Seneca, depending on their program, are required to complete an English-language placement test (comprising a 300-word essay) to assess writing proficiency. Students must also complete a computerized placement test (Accuplacer) that assesses reading comprehension (120-point scale), though it is rarely used for course placement decisions. Based on their test results, students are placed in one of several levels of English-language courses:

1. ELL-1. Non-credit English for English Language Learners, at three levels of proficiency below college-level English;
2. ELL-2. Non-credit English for English Language Learners (ELL), at two levels of proficiency below college-level English;
3. Below college English/ELL-3. Non-credit English for both native-English speakers and for ELL learners at the more proficient end of the ELL scale;
4. College-level English (credit). Required for all certificate/diploma programs;
5. Degree-level English (credit). Applicable to some degree programs; and
6. Exempt from college-level English. At high end of proficiency scale.

For the purposes of this study, three categories of English-language proficiency were created (based on the above categories):

1. Below college-level English – ELL (levels 1 & 2);
2. Below college-level English – ELL (level 3)/non-ELL; and
3. At/above college-level English (level 4, 5 & 6).

College Performance

Overall GPA was calculated from the average of all credit courses ever taken at Seneca, up to the first credential completed. GPAs were grouped into four categories: <2.0; 2.0 to < 3.0; 3.0 to < 3.5; and ≥3.5. A separate GPA was calculated for all validated first-year college math courses taken excluding foundation math. An average was calculated for all coursework completed, and for all math coursework completed, using a midpoint formula on a 4-point scale and/or 100-point scale. A separate variable was defined by whether a student was placed in a foundation college math course.

Proportion of Students Who Graduated

The proportion of students who graduated was calculated by defining graduation as the completion of the first college program in which a student was observed within the standard program length plus one full academic year. A student who did not complete the credential in the allotted period was considered in-progress.

Postgraduate Outcomes

Post-graduation outcomes were obtained from the GSS administered by MTCU[19] to all college graduates with an Ontario College Credential (OCC).[20] The survey is administered approximately six months after graduation through telephone surveys conducted by an external service provider to whom the colleges provide contact information and graduate characteristics such as age, gender, and program of study. The survey asks graduates about their education and labour market activity during a reference week six months after graduating.

This study used the following variables from the GSS:

- **Transfer to university:** Enrolled in any university (full or part time) in the reference week six months after graduation.
- **Employment:** Percentage in the labour force who are working during the reference week six months after graduation. The labour force is defined as those who are available to work and are either looking for work or working.
- **Hourly wage:** Those employed full or part time and reporting an hourly wage of between $2 and $100 were considered valid.[21] Ontario's Consumer Price Index (CPI) was used to adjust wages for inflation to 2014 dollars. The natural log of real hourly wage (in dollars) was used in regression analyses.
- **Overqualification (education required for job):** Graduates who were employed (full or part time) were asked to indicate the minimum education level required for their job at hiring. This information was compared with the graduate's college credential to determine whether the graduate was overqualified. Graduates were considered overqualified if the required credential was less than a diploma or certificate.
- **Related job:** Graduates indicated whether their current job was either related or very related to their field of study.

Analytic Methods

The study used both descriptive and regression techniques to estimate the effect of math proficiency on college performance and post-graduation prospects. Descriptive results for each outcome of interest are presented by selected characteristics. To control for the independent effects of each variable, regression models were used for each outcome of interest: Linear regression with robust standard errors was used when the outcome of interest was a continuous variable; logistic regression was used when the outcome of interest was a dichotomous categorical variable. For all regression analyses, the dataset was restricted to individuals with complete data for all variables included in the regression model. Details on the model building methodology are in appendix 2.

Results

Profile of high school math background of college entrants

Despite having a destination-related curriculum in Ontario high schools, Seneca students have taken workplace, college and university preparation courses. In grade 11, the most common course taken was at the college preparation (44%). However, a high proportion of students took the mixed

[19] See MTCU's Graduate and Employer KPI Surveys operating guide, http://www.tcu.gov.on.ca/pepg/documents/GraduateandEmployerKPISurveys2015-16SurveyCycle.pdf

[20] This designation applies only to graduates from a publicly funded College of Applied Arts and Technology (CAAT) in Ontario.

[21] The MTCU data cleanup protocol has established this range as valid.

college/university grade 11 math course (M), and one-quarter took the university preparation course. Likewise in grade 12, the most common course taken was the Foundations for College Math (Personal Finance for Students, pre-2007). However, a significant share of students took a range of grade 12 university preparation courses as well. College students who took grade 12 university preparation courses obtained lower grades and had higher failure rates than those who workplace preparation math courses or college preparation math.

*Table 2. **High school math courses taken and grades obtained,** Seneca students from an Ontario high school, **2007-2014***

Grade	Course Code	Course Name	N	% who took course	Average Grade	95% CI	% failures
11	MEL3E	Mathematics for Everyday Life	2,699	7.9%	70.3	69.8, 70.8	1.7%
	MBF3C	Mathematics of Personal Finance*/ Foundations for College Math	15,013	43.7%	66.0	65.8, 66.3	2.4%
	MCF3M	Functions	11,446	33.3%	62.0	61.7, 62.3	8.2%
	MCR3U	Functions and Relations	8,728	25.4%	61.7	61.4, 62.0	9.8%
12	MEL4E	Mathematics for Everyday Life	864	2.5%	70.4	69.5, 71.3	2.8%
	MAP4C	College and Apprenticeship Mathematics*/ Foundations for College Math	11,529	33.5%	68.6	68.4, 68.9	3.6%
	MCT4C	Mathematics for College Technology	1,888	5.5%	67.7	67.0, 68.4	6.3%
	MDM4U	Mathematics and Data Management	5,791	16.8%	61.6	61.2, 62.0	13.1%
	MCV4U	Calculus and Vectors	2,111	6.1%	64.0	63.3, 64.7	12.9%
	MHF4U	Advanced functions	4,669	13.6%	64.3	63.9, 64.8	11.0%
	MCB4U	Advanced Functions and Introductory Calculus*	1,839	5.3%	61.8	61.0, 62.6	17.7%
	MGA4U	Geometry and Discrete Mathematics*	449	1.3%	64.6	62.9, 66.3	16.0%

Notes: Courses/course names offered pre-2007: MBF3C and MAP4C kept the same codes but changed course titles; MCB4U and MGA4U were discontinued and replaced with MCV4U and MHF4U;Note: Total proportions by grade may add up to more than 100% because students may take multiple math courses at each grade level: CI is the confidence interval

Sociodemographics

Being younger, female, a Canadian citizen, having English as a first language, and not having a university-educated parent (or not knowing parent's level of education) are each associated with a lower incidence of taking more advanced math courses in high school (Table 3). Neighbourhood income and OSAP receipt differed little by math course selection.

Female students were particularly less likely than male students (54% vs.74%) to take a grade 12 university preparation or college preparation math course, but of those who did, females were just as likely as males to take a university preparation course. Canadian citizens were less likely than non-Canadian citizens to take grade 12 math, and those who did so were less likely than non-Canadian citizens to take a university preparation level. Students who indicated that one of their parents had a university degree were only slightly more likely to take a grade 12 math, but far more likely to take a university preparation math in grade 12, compared with students who did not a have university-educated parent. Similarly, students reporting English as a first language were less likely to take a grade 12 university preparation math compared with students whose first language was English. Older students, likely associated with having previous university attendance, were more likely than younger students to take a grade 12 university preparation math.

Table 3. Sociodemographic background by most advanced course taken in high school, Seneca students from an Ontario high school, 2007-2014.

			Highest High School Math Course Taken				
		N	**11/12 E**	**11 C**	**11 U or M**	**12 C**	**12 U**
Age at entry (yr.)	<19	15,970	5.2%	15.8%	14.1%	40.5%	24.5%
	19	8,762	5.8%	16.5%	14.9%	33.7%	29.2%
	20-<23	9,647	6.7%	15.0%	14.6%	27.4%	36.2%
Gender	Female	17,140	7.9%	20.7%	17.5%	29.7%	24.2%
	Male	17,184	3.7%	10.7%	11.4%	40.4%	33.7%
Status in Canada	Citizen	30,952	6.0%	16.5%	14.5%	35.4%	27.6%
	Non-Canadian Citizen	3,177	3.8%	8.2%	14.0%	32.1%	41.9%
English as a first language	Yes	23,568	6.4%	17.7%	14.6%	36.4%	25.0%
	Other	10,811	4.4%	11.5%	14.2%	32.2%	37.7%
Parental education	Degree	8,017	3.7%	12.7%	16.6%	27.9%	39.1%
	No degree & Unknown	26,362	6.4%	16.7%	13.8%	37.3%	25.9%
Neighbourhood income	Low	11,656	6.3%	16.7%	15.0%	33.2%	28.9%
	Middle	12,351	5.9%	15.9%	14.0%	35.7%	28.5%
	High	9,858	5.0%	14.6%	14.5%	36.7%	29.3%
OSAP recipient	No	17,323	5.2%	15.2%	14.4%	35.4%	29.7%
	Yes	17,056	6.3%	16.3%	14.5%	34.7%	29.2%
Total		34,379	5.8%	15.7%	14.4%	35.1%	29.0%

Note: Missing data includes: 55 students for gender; 250 students for citizenship; and 514 students for neighbourhood income.

Academic background and previous education

As would be expected, students who took university preparation math were also far more likely to have taken mostly U or U/C courses (defined as a minimum of 50% U or U/C), and to meet minimum university requirements for admission (

Table 4). However, grades obtained in high school do not show a clear pattern. Students who took workplace math or grade 11 college preparation math as their highest math comprise a reduced share of those with overall averages of over 70%, whereas those who took a 12 university preparation course comprised a slightly higher share. With respect to failure rates, there is some indication, as seen previously in Table 2, that students who took university preparation math in either grade 11 and 12 also struggled to pass their courses.

Table 4. High school background by most advanced course taken in high school, Seneca students from an Ontario high school, 2007-2014

			Highest High School Math Course Taken				
		N	**11/12 E**	**11 C**	**11 U or M**	**12 C**	**12 U**
High school courses mostly U or M	No	15,251	11.2%	22.1%	6.1%	57.3%	3.4%
	Yes	19,128	1.5%	10.7%	21.1%	17.4%	49.4%
High school average	<60%	2,251	10.0%	22.8%	13.9%	34.9%	18.4%
	60-69%	16,742	6.5%	17.2%	14.5%	34.7%	27.0%
	70-79%	12,835	4.6%	13.6%	14.1%	35.8%	31.9%
	≥80%	2,551	3.2%	10.9%	16.0%	33.7%	36.3%
How many 11/12 courses did a student fail?	0	17,873	5.4%	15.1%	12.2%	38.6%	28.6%
	1-3	12,265	6.0%	16.4%	16.8%	32.3%	28.5%
	>3	4,241	6.7%	16.4%	16.9%	28.1%	31.9%
Eligible for university	No	27,435	7.0%	17.4%	12.9%	42.3%	20.4%
	Yes	6,944	1.1%	9.1%	20.7%	6.4%	62.7%
Total		34,379	5.8%	15.7%	14.4%	35.1%	29.0%

Table 5 shows that most students with previous university had taken grade 12 university preparation math (73%). Students who entered college with plans for university were somewhat more likely than those without university plans to have taken a grade 12 university preparation course, indicating they may have had aspirations in high school.

Table 5. Previous university attended and plans for university after graduation, Seneca students from an Ontario high school, 2007-2014

			Highest High School Math Course Taken				
		N	**11/12 E**	**11 C**	**11 U or M**	**12 C**	**12 U**
Last school attended	No	31,912	6.2%	16.5%	14.2%	37.6%	25.6%
	Yes	2,467	0.9%	6.5%	17.4%	2.7%	72.5%

was university							
Aspired to attend university	No	18,904	6.7%	15.9%	13.9%	38.4%	25.2%
	Yes	15,427	4.7%	15.6%	15.1%	30.9%	33.6%
	Missing data	48	4.2%	14.6%	6.3%	56.3%	18.8%

Selection into college programs requiring math

Table 6 shows the sociodemographic characteristics of students who selected college programs requiring math, including students who took a first-year math course and those whose first program was in the technology area. More than one-half (53%) of Seneca students from an Ontario high school took a math course in first year and 16% entered a technology program. Of students who took a math course in first year, a larger proportion were 19 years and older at entry, male, non-citizens, spoke a first language other than English and had a least one parent with a degree; there was very little difference in neighbourhood income or receipt of OSAP. Canadian citizenship, however, had the largest effect: considerably more non-citizens took a first-year math course than did citizens (72% vs. 52%).

For technology program selection, similar patterns were seen. However, there was no difference by age, and an extremely large difference by gender, with only 6% of female students entering a technology program compared with 26% of males.

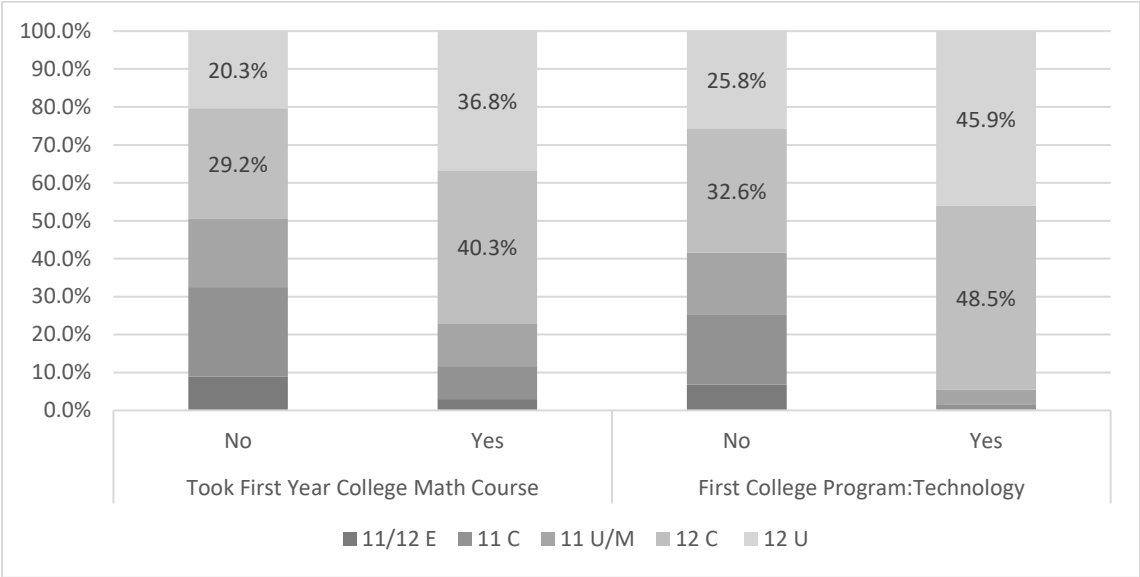
Table 6. Sociodemographic profile of students who entered programs requiring math, Seneca students from an Ontario high school, 2007-2014

		Took a First-Year College Math Course N=34,379		First Program was Technology N=34,379	
		Prop. (%)	95% CI	Prop. (%)	95% CI
Age at entry (yrs.)	<19	49.7	49.0, 50.5	15.7	15.1, 16.3
	19	54.1	53.0, 55.1	15.7	15.0, 16.5
	20- <23	56.2	55.2, 57.2	15.7	15.0, 16.4
Gender	Female	45.4	44.7, 46.2	5.9	5.5, 6.2
	Male	59.9	59.2, 60.6	25.6	24.9, 26.2
	Missing	50.9	37.1, 64.6	3.6	0.4, 12.5
Status in Canada	Citizen	51.3	50.8, 51.9	15.4	15.0, 15.8
	Non-Canadian Citizen	65.0	63.3, 66.7	19.0	17.7, 20.5
	Missing	59.2	52.8, 65.4	13.6	9.6, 18.5
English as a first language	Yes	49.0	48.4, 49.7	14.6	14.1, 15.0
	Other	60.6	59.7, 61.5	18.2	17.5, 19.0
Parental education	Degree	56.5	55.4, 57.6	18.8	18.0, 19.7
	No Degree/ Unknown	51.5	50.9, 52.1	14.8	14.3, 15.2
Neighbourhood income	Low	54.1	53.2, 55.0	16.4	15.8, 17.1
	Middle	51.8	50.9, 52.7	15.2	14.6, 15.9
	High	51.7	50.7, 52.7	15.3	14.6, 16.1
	Missing	59.9	55.5, 64.2	17.7	14.5, 21.3
OSAP recipient	Yes	53.7	52.9, 54.4	16.1	15.5, 16.6
	No	51.7	50.9, 52.4	15.3	14.8, 15.9

Notes: Technology group is a subset of the "took first-year math group"; CI = confidence interval

Figure 2 shows that 77% of students who entered a college program requiring math also took grade 12 math in high school, whereas only 49% of students who entered a program requiring math had taken a grade 12 math course. Almost all students who entered a technology program in college had taken a grade 12 math, of which almost half were at a university preparation level. Much of this high school course selection can be attributed to college program requirements, many of which require grade 12 math for admission, particularly in technology programs.

Figure 2. Selection of program requiring math by most advanced course taken in high school, Seneca students from an Ontario high school, 2007-2014



Students who entered programs requiring math had somewhat weaker high school backgrounds, with greater numbers of course failures, and lower overall averages: 57% of students with averages below 60% entered a program requiring math compared with 45% of those with averages above 80% (Table 7). Previous university attendance had little effect on whether the student entered a college program requiring math. Students with averages below 60% and those with multiple course failures were less likely to choose a college program in a technology field. Students who previously attended university were more likely to enter a college program in a technology field.

Table 7. Academic background of students who entered programs requiring math, Seneca students from an Ontario high school, 2007-2014

		Took a First-Year College Math Course N=34,379		First Program was Technology N=34,379	
		Prop. (%)	95% CI	Prop. (%)	95% CI
High school courses mostly U or M	No	50.0	49.2, 50.8	14.5	14.0, 15.1
	Yes	54.8	54.1, 55.5	16.7	16.1, 17.2
High school average	<60%	57.1	55.0, 59.1	11.6	10.3, 12.9
	60-69%	54.9	54.2, 55.7	15.3	14.8, 15.9
	70-79%	50.4	49.5, 51.3	17.0	16.3, 17.7
	≥80%	45.4	43.4, 47.3	15.5	14.1, 17.0
High school math average	<60%	50.7	49.9, 51.6	12.1	11.6, 12.8
	60-69%	54.5	53.6, 55.5	18.4	17.7, 19.2
	70-79%	54.5	53.4, 55.6	18.0	17.2, 18.9
	≥80%	50.1	48.6, 51.7	15.0	13.9, 16.1
How many 11/12 courses did a student fail?	None	49.5	48.7, 50.2	16.2	15.7, 16.8
	1-3	54.6	53.7, 55.5	15.2	14.6, 15.9
	>3	60.6	59.0, 62.0	14.9	13.8, 16.0
Eligible for university	No	53.1	52.5, 53.7	15.4	15.0, 15.8
	Yes	50.9	49.7, 52.1	16.9	16.1, 17.8
Last school attended was university	No	52.6	52.0, 53.1	15.4	15.0, 15.8
	Yes	53.7	51.8, 55.7	20.1	18.6, 21.8

Note: CI = confidence interval

Regression results

The regression and descriptive analyses showed similar results with regard to factors associated with selection of program requiring math. Results of the multivariable regression analysis suggest a positive association of high school math average and advanced math courses with entering a program requiring math or a technology field (Table 8). In contrast, college entrants with overall stronger high school performance were less likely to select a program requiring math.

Results of the multivariable regression analysis also suggest that, when controlling for high school math and other selected variables, students who are less likely to select a program requiring math are: female, Canadian citizens, younger and have English as a first language. Neighbourhood income and parental education did not have a significant effect. Students who had previously been to university were less likely to choose a program containing math, whereas those who planned to attend university were more likely.

Results also showed that selection into a technology program differed from selection into the broader "math-required" programs. Advanced math course selection in high school had a much stronger effect on

college program selection: the odds of selecting a technology program were seven times greater among those who had taken a grade 12 university preparation math course compared with those who had not.

Students who had a parent with a degree and those from lower income neighbourhoods were more likely to select a technology program. The odds of selecting a technology program were almost five times higher for male students compared with female students, whereas citizenship, first language and age were not significant factors.

Table 8. Regression analysis: The effect of high school academic background on college program selection, Seneca students from an Ontario high school, 2007-2014

VARIABLES	LABELS	Program containing math	Technology
High school math course average	Value (20-100%)	1.018***	1.018***
		(0.001)	(0.002)
Took grade 12 U math	Yes	2.373***	7.097***
		(0.106)	(0.695)
Took grade 12 C math	Yes	1.849***	5.242***
		(0.085)	(0.524)
Took grade 11 U or M math (no grade 12 math)	Yes	1.107	1.558***
		(0.075)	(0.230)
Took grade 11 C math (no grade 12 math)	Yes	0.572***	0.378***
		(0.029)	(0.057)
Took grade 11/12 workplace math	Yes	0.446***	0.150***
		(0.031)	(0.045)
How many grade 11 & 12 courses did a student fail? (Ref: none)	1-3 courses	1.157***	
		(0.033)	
	More than 3 courses	1.325***	
		(0.059)	
Citizenship (Ref: non-Canadian citizen)	Canadian	0.821***	
		(0.039)	
First language was English (Ref: other)	Yes, English	0.845***	
		(0.025)	
Age starting college (Ref: <19 years)	19 years	1.166***	1.005
		(0.036)	(0.041)
	20-<23 years	1.380***	0.990
		(0.045)	(0.040)
Student gender (Ref: female)	Male	1.210***	4.659***
		(0.031)	(0.182)
Parental education (Ref: parent has no degree/unknown)	Degree		1.219***
			(0.046)
Income (Ref: low income)	Mid Income		0.852***
			(0.033)
	High Income		0.766***
			(0.032)
Senior HS course type (Ref: mostly C/W level)	Mostly U Level	0.876***	0.885***
		(0.028)	(0.041)
Senior HS GPA (Ref: <60%)	60-69%	0.795***	1.226***
		(0.042)	(0.094)
	70-79%	0.614***	1.293***
		(0.036)	(0.107)
	>=80	0.441***	1.107
		(0.034)	(0.120)
Was last school attended a University? (Ref: no)	Yes	0.855***	
		(0.045)	

Did the student plan to go to university? (Ref: no)	Yes	1.885***	
		(0.048)	
Entering credential (Ref: 2-year diploma)	Certificate 1 yr	0.448***	
		(0.017)	
	Advanced Diploma 3 yr	1.318***	
		(0.056)	
CPT placement: English (Ref: ELL level 1 or 2)	Below College/ ELL – Level 3	1.011	1.044
		(0.056)	(0.068)
	College English/Exempt	0.934	0.934
		(0.054)	(0.061)
Academic year of entry (Ref: 2007-08)	2008-09	0.991	0.960
		(0.049)	(0.064)
	2009-10	0.907**	1.037
		(0.044)	(0.068)
	2010-11	0.922	1.100
		(0.044)	(0.071)
	2011-12	0.815***	1.008
		(0.040)	(0.067)
	2012-13	0.812***	1.175**
		(0.039)	(0.075)
	2013-14	0.924	1.197***
		(0.045)	(0.077)
	2014-15	0.718***	1.220***
		(0.037)	(0.083)
Term of entry (Ref: winter)	Summer	0.495***	0.625***
		(0.044)	(0.079)
	Fall	0.863***	1.029
		(0.032)	(0.051)
Constant		0.564***	0.005***
		(0.072)	(0.001)
Observations		34,031	33,811
Pseudo R-squared		0.144	0.1854

Notes: Robust standard errors in parentheses; *** p<0.01, ** p<0.05; “math required” includes all students who took first-year math.

Effect of high school background on college placement scores and overall college achievement

Math proficiency at college entry

Test scores in arithmetic, algebra and CAT-3 for entering students who took a first-year math course showed that students had a wide range of math ability (Figure 3). Over half of the students had less than

basic arithmetic level and, 58% tested at lower than minimal elementary algebra. CAT-3 results showed that two-thirds of students scored in the bottom half of the national percentile for grade 12 students.

Figure 3. Distribution of standardized math assessment scores, Seneca students from an Ontario high school, 2007-2014

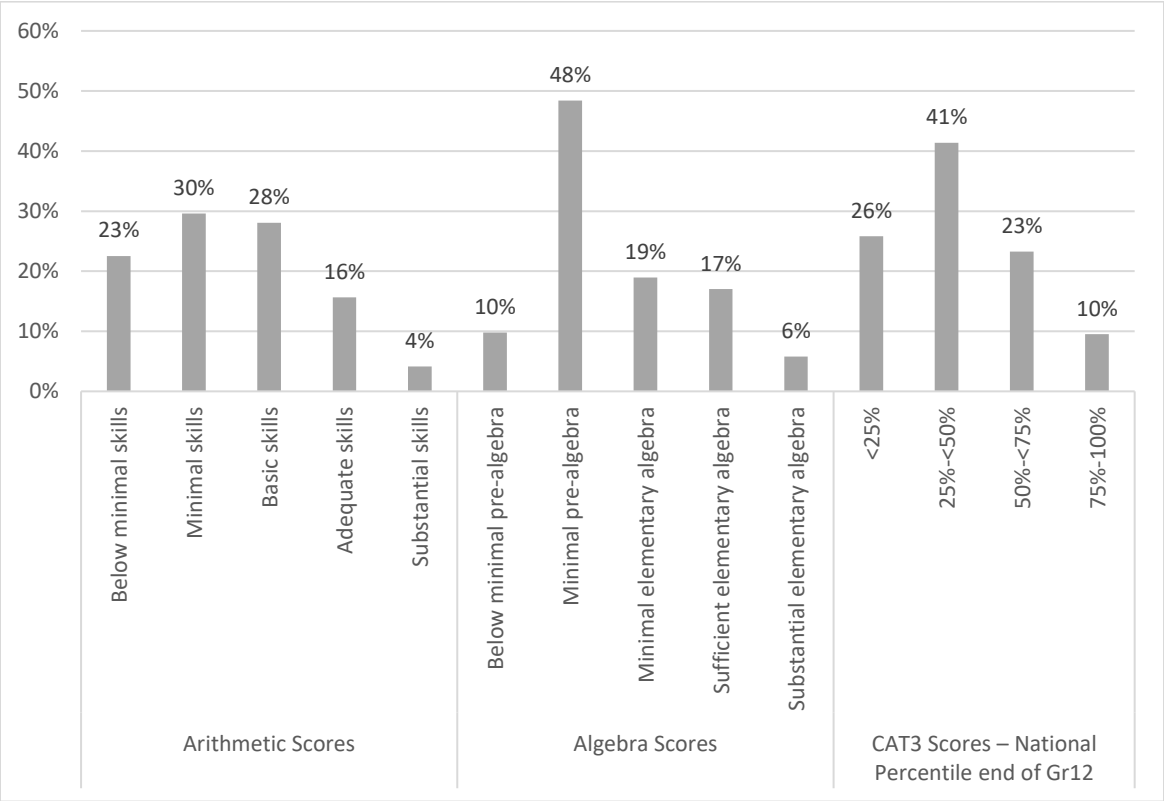


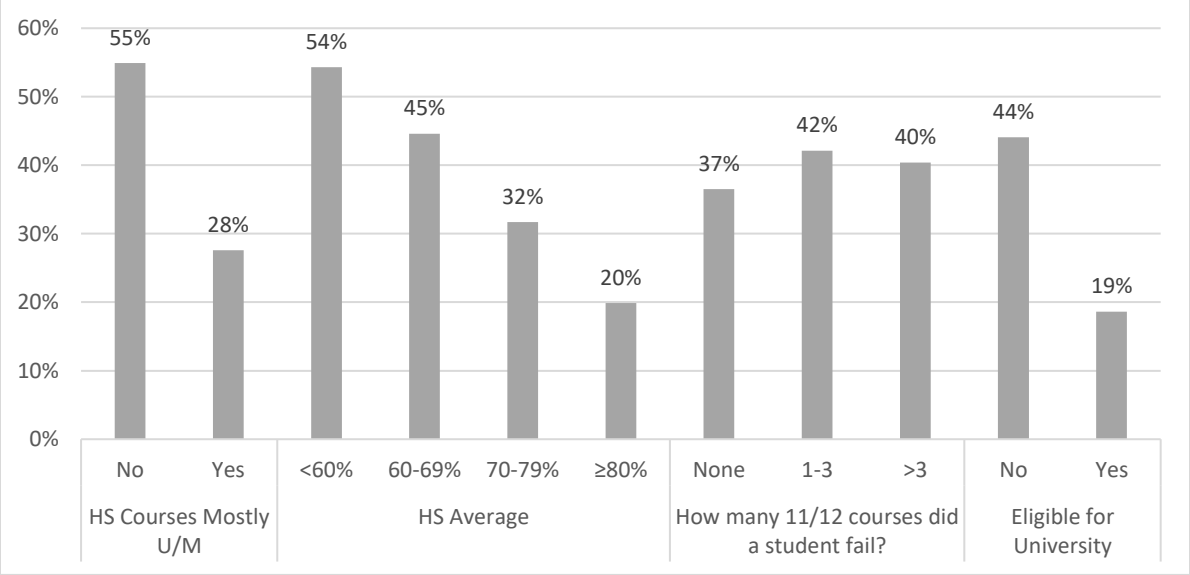
Table 9 shows that students who took university preparation courses in high school achieved higher overall test scores at college entry. Students who obtained the minimum requirement for university entry (70% in 6 U or M) outperformed other students in each of the standardized math tests. However, test scores differed little by the total number of high school courses failed, likely because of the challenge and the increased risk of failure associated with more advanced courses. Figure 4 shows a similar pattern in test scores for the proportion of students placed in foundation math courses.

Table 9. High school academic background of Seneca entrants from an Ontario high school, by standardized test scores, 2007–2014

		Arithmetic Scores /120 N=13,440		Algebra Scores /120 N=12,166		CAT-3 Scores N=7,764	
		Mean	95% CI	Mean	95% CI	Mean	95% CI
High school courses mostly U or M	No	47.7	47.0, 48.3	43.4	42.9, 44.0	568.9	567.1, 570.7
	Yes	67.2	66.6, 67.9	63.9	63.3, 64.6	621.0	619.3, 622.7
High school average	<60%	51.4	49.8, 53.1	46.6	45.1, 48.1	569.3	564.1, 574.5
	60-69%	56.4	55.7, 57.0	52.7	52.0, 53.3	587.9	588.0, 589.9
	70-79%	62.0	61.1, 62.8	59.2	58.4, 60.1	606.6	604.5, 608.7
	≥80%	73.6	71.4, 75.7	70.9	68.6, 73.1	630.5	625.4, 635.6
How many 11/12 courses did a student fail?	0	59.7	59.0, 60.4	56.5	55.7, 57.2	601.9	600.0, 603.8
	1-3	57.3	56.5, 58.1	53.8	53.0, 54.5	592.2	590.0, 594.5
	>3	60.3	59.1, 61.6	55.9	54.7, 57.1	593.1	589.4, 596.8
Eligible for university	No	55.5	55.0, 56.0	51.7	51.2, 52.2	587.2	585.7, 588.6
	Yes	74.0	72.8, 75.2	71.6	70.4, 72.8	637.7	635.0, 640.4

Note: Only entrants with a minimum of 6 Ontario grade 11 or 12 courses are included. The CAT-3 scores were converted from a number-correct to a linear scale (Appendix 1); CI= Confidence interval

Figure 4. Proportion of Seneca students from an Ontario high school placed in foundation math by high school academic background, 2007–2014



Notes: N=18,109. Only those with a minimum of 6 Ontario grade 11 or 12 courses are included.

Figure 5 and Figure 6 show the relationships between level of math course taken in high school and performance on college assessment tests. Students with higher math proficiency test scores were more likely to have taken more advanced courses in high school. For example, the majority of students who tested at the "adequate" or "substantial" skill level in arithmetic (62% and 73% respectively) had taken a grade 12 university preparation course in high school. For algebra, the effect of university preparation courses is more profound: 67% of those who tested at the sufficient level and 91% at the substantial level had taken grade 12 university preparation math. Although the pattern for the CAT-3 testing is similar, one difference is the greater share of students who took a grade 12 university preparation or C math, a requirement of most college technology programs. The results clearly show the imbalance in performance between the grade 12 college and university preparation courses: 82% of those who had taken grade 12 university preparation math scored in the top 25th percentile relative to Canadian student norms, whereas 62% of students who had taken grade 12 college preparation math scored in the lowest 25th percentile.

Figure 5. Algebra and arithmetic Accuplacer scores by most advanced course taken in high school, Seneca students from an Ontario high school, 2007-2014

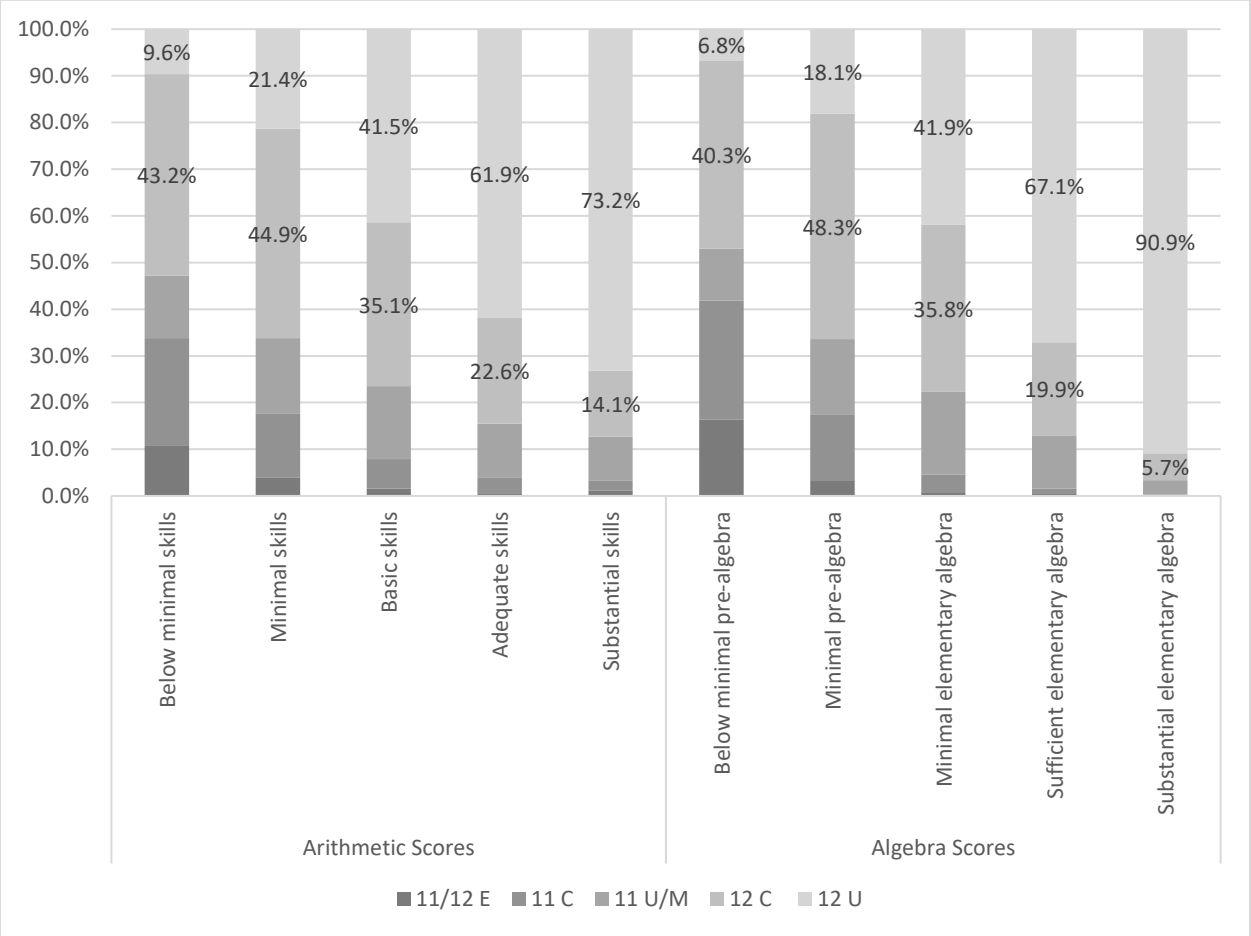


Figure 6. CAT-3 (level 19) scores by most advanced math course taken in high school, Seneca students from an Ontario high school, 2007-2014

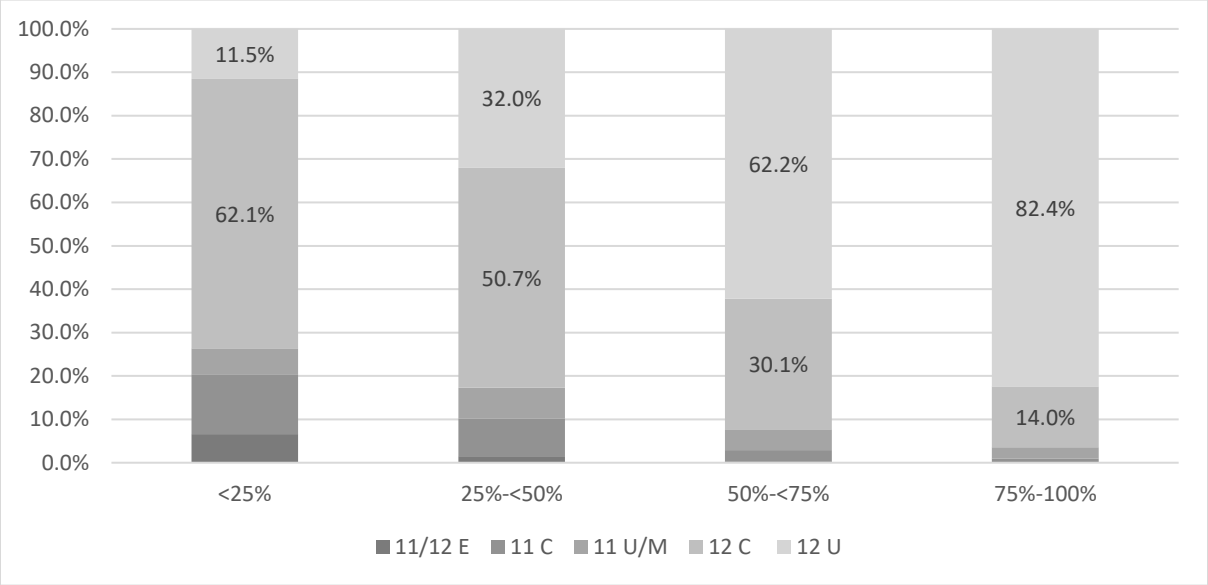
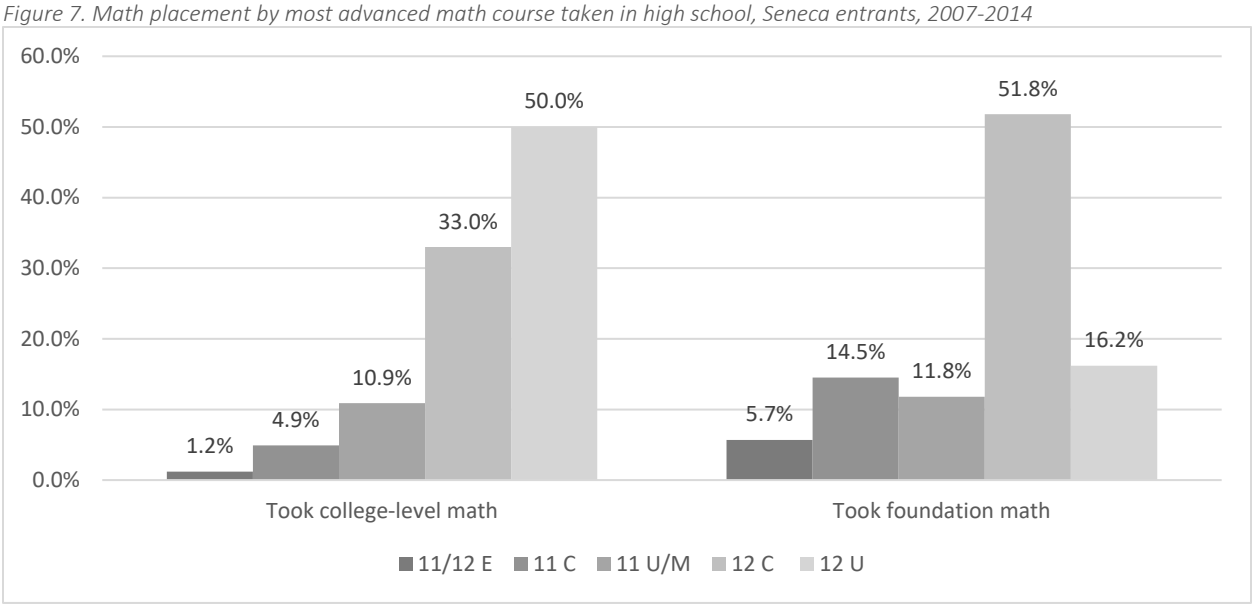


Figure 7 shows the distribution of the most advanced math course taken in high school by placement in college-level or foundation math. Of those who were placed in college-level math, 50% had taken a grade 12 university preparation course, compared with only 16% of those placed in foundation math.

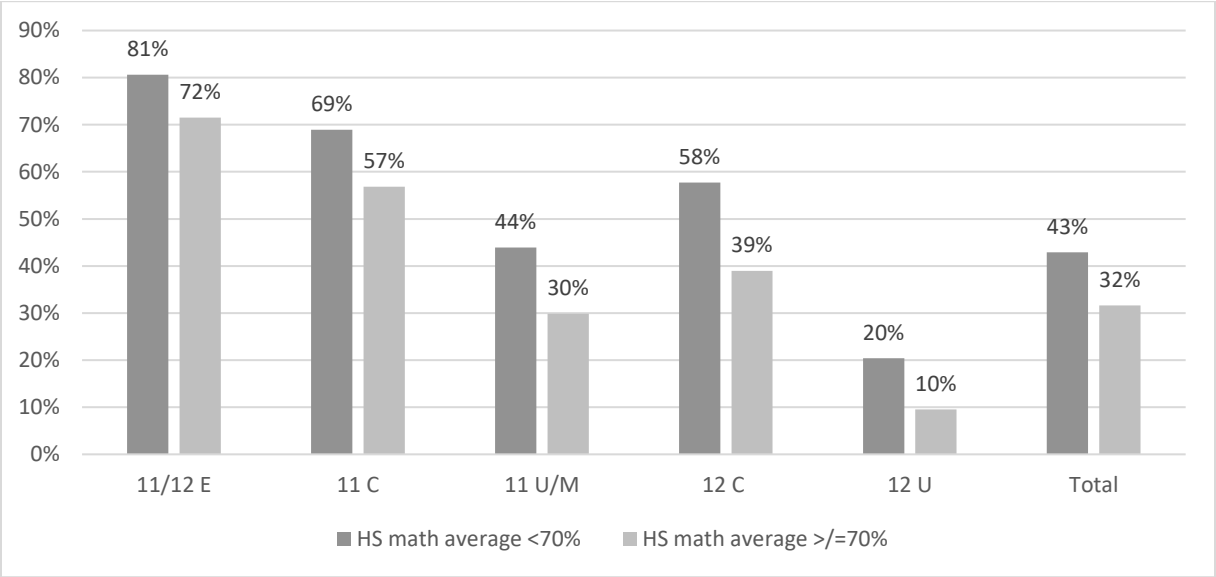
Figure 7. Math placement by most advanced math course taken in high school, Seneca entrants, 2007-2014



Overall high school math averages were also analysed (Figure 8). The majority of students with high school math averages above 70%, who took grade 11 or 12 workplace preparation math or grade 11 college preparation math as their most advanced math course, were placed in foundation math. Despite obtaining a high school math average above 70%, 39% of students who took a grade 12 college preparation math were assessed at a foundation math level. In contrast, among those who took grade 12

university preparation math, only 10% of those who obtained a math average over 70% were placed in foundation math.

Figure 8. Percentage of students placed in foundation math by most advanced math course taken in high school and high school math average, Seneca entrants, 2007-2014



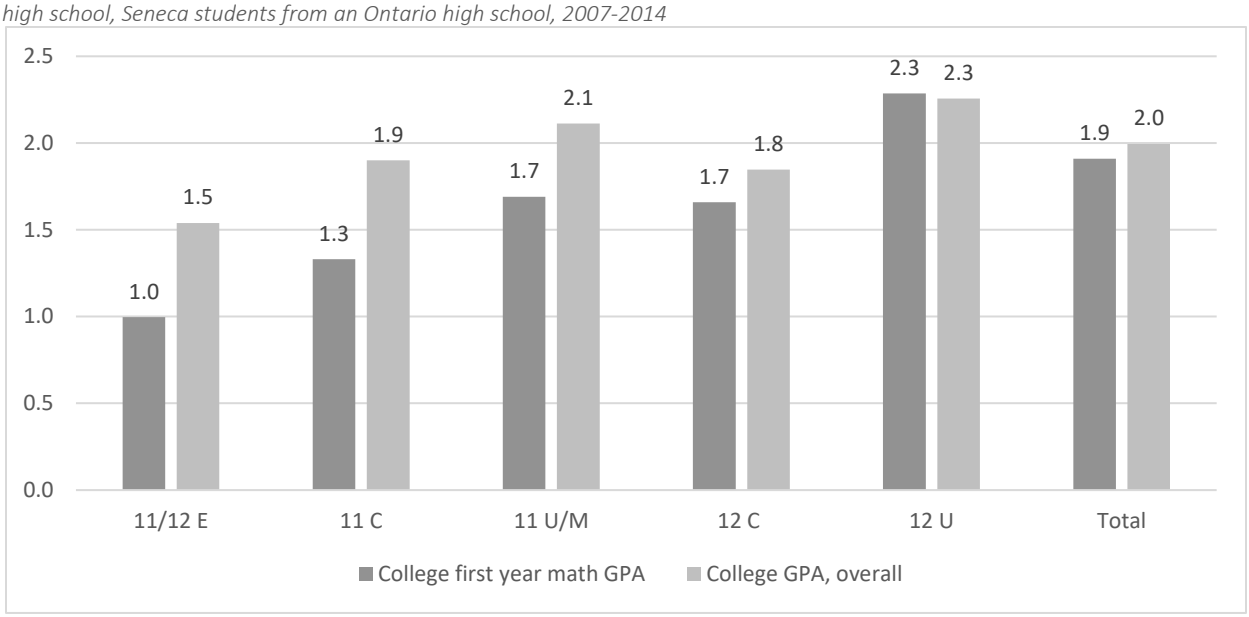
Academic outcomes by type of high school math courses taken

The results show that selection of a more advanced high school math course is associated with a higher college GPA average in first-year math (Figure 9). Those who took a grade 12 university preparation math obtained a first-year math GPA of 2.30, whereas those who took grade 11 or 12 workplace math had a

first-year math GPA of 1.0. The type of high school math selected had a similar but lesser effect on the overall college GPA (which also included students who did not take first-year math in college).

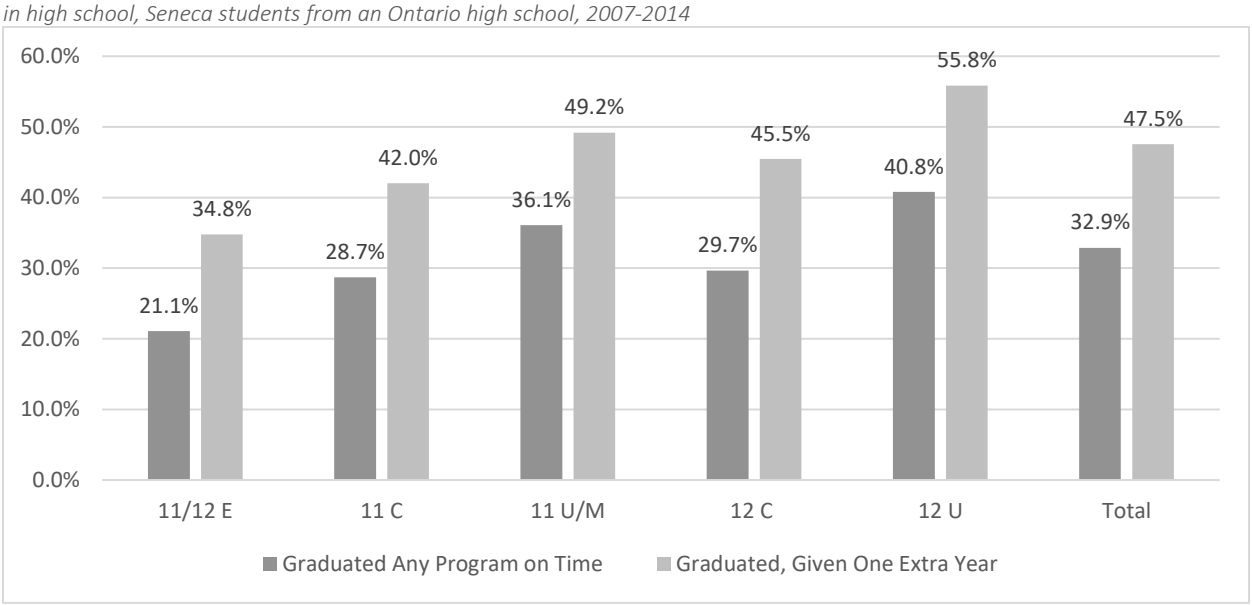
Overall, higher college graduation rates are associated with the selection of more advanced math high school; graduation rates were higher for students who took grade 11 or 12 university preparation math compared with students who took grade 11 or 12 college or workplace preparation math (Figure 10).

Figure 9. Average first year-college math GPA and overall college GPA on a 4-point scale, by most advanced math course taken in high school, Seneca students from an Ontario high school, 2007-2014



Notes: N=13,250 for first-year math GPA. For overall GPA, N=34,060, including those who may or may not have taken first-year math.

Figure 10. Proportion of Seneca students who graduated on time and given one extra year, by most advanced math course taken in high school, Seneca students from an Ontario high school, 2007-2014



Notes: N=20,904 for graduating on time. N=20,805 for graduating in one additional year; includes those who may or may not have taken first-year math.

Regression results

College Placement Scores

Linear regression was used to estimate the effect of high school math average on college placement scores (algebra, arithmetic, and CAT-3), whereas logistic regression was used to estimate the effect of high school math average on placement in foundation math in first-year college (Table 10). Overall, the results show that with increases in high school math averages, college math placement scores increase, decreasing the odds of being placed in foundation math. Taking a grade 12 university preparation math or grade 11 university or university/ college preparation math course resulted in higher average placement scores, whereas taking grade 11 college preparation math or grade 11 or 12 workplace preparation (E) math resulted in lower average placement scores. In terms of overall high school and educational background, taking mostly university preparation courses in high school, obtaining higher overall high school GPAs, and previously attending a university were associated with higher math placement scores and a lower odds of being placed in foundation math. Interestingly, failing one or more high school courses was associated with higher placement scores and lower odds of being placed in foundation math, perhaps as a result of attempting and persisting with more advanced courses.

Across most models, entering college at 19 years of age or older, being male, or having a parent with a degree, were positively associated with an increase in the average college math placement scores and a decrease in the odds of being placed in foundation college math. Alternatively, being a Canadian citizen, speaking English as a first language, and coming from a low income neighbourhood, were negatively associated with math placement scores and positively associated with the odds of placement in foundation math. However, citizenship and age were not significant for CAT-3 scores and income was not significant for algebra scores or the odds of foundation math placement. A time trend was also evident, with those entering college in more recent years being more likely to score lower on the placement tests relative to 2007-08.

Placement in college English had different effects across assessments, likely because non-Canadian citizens in the sample were much less likely than citizens to have English as a first language, yet often had very strong math skills. Test scores for arithmetic were higher for students placed in the lowest levels of English for English-language learners (ELL 1 & 2) than for those placed in foundation English, at a level below college-level English. Algebra test scores were highest for those placed in the lowest levels of English (ELL 1 & 2). However, test scores for CAT-3 (for technology students) mirrored the English-language assessment scores, with higher CAT-3 scores associated with a higher level of English-language placement.

Table 10. Regression analysis: The effect of high school math academic background on college math placement scores (arithmetic, algebra and CAT-3) and placement in a foundational math course, Seneca students from an Ontario high school, 2007-2014

VARIABLES	LABELS	Arithmetic Scores	Algebra Scores	CAT-3 Scores	Foundation Math Placement
High school math course average	Value (20-100%)	0.470***	0.430***	1.098***	0.965***
		(0.023)	(0.021)	(0.067)	(0.002)
Took grade 12 U math	Yes	17.356***	21.203***	35.214***	0.201***
		(0.775)	(0.667)	(2.891)	(0.014)
Took grade 12 C math	Yes	-0.620	-1.021	-5.109	0.918
		(0.792)	(0.657)	(2.893)	(0.063)
Took grade 11 U or M math (no grade 12 math)	Yes	12.174***	11.927***	22.113***	0.417***
		(1.249)	(1.071)	(4.677)	(0.046)

Took grade 11 C math (no grade 12 math)	Yes	-7.968***	-8.814***	-16.504***	2.611***
		(0.867)	(0.693)	(3.267)	(0.220)
Took grade 11/12 workplace math	Yes	-14.460***	-15.484***	-43.097***	5.372***
		(1.095)	(0.985)	(4.808)	(0.693)
How many grade 11 & 12 courses did a student fail? (Ref: none)	1-3 courses	1.635***	0.933**	3.833***	0.919**
		(0.483)	(0.430)	(1.334)	(0.039)
	More than 3 courses	3.826***	3.649***	9.373***	0.792***
		(0.718)	(0.631)	(1.997)	(0.049)
Citizenship (Ref: non-Canadian citizen)	Canadian	-5.955***	-9.673***		1.461***
		(0.772)	(0.746)		(0.094)
First language was English (Ref: other)	Yes	-2.395***	-6.121***	-6.500***	1.225***
		(0.478)	(0.441)	(1.282)	(0.051)
Age starting college (Ref: <19 years)	19 years	2.913***	1.803***	0.780	0.882***
		(0.513)	(0.451)	(1.389)	(0.039)
	20-<23 years	5.908***	3.264***	1.674	0.843***
		(0.546)	(0.483)	(1.470)	(0.040)
Student gender (Ref: female)	Male	12.240***	4.572***	17.999***	0.713***
		(0.432)	(0.378)	(1.208)	(0.028)
Parental education (Ref: no degree or unknown)	Degree	1.175**	1.136**	3.061**	0.914**
		(0.503)	(0.446)	(1.263)	(0.039)
Neighbourhood Income (Ref: low income)	Mid Income	1.230**		5.960***	
		(0.485)		(1.311)	
	High Income	1.171**		7.280***	
		(0.525)		(1.424)	
Senior high school course type (Ref: mostly C/W level)	Mostly U Level	5.788***	6.468***	17.718***	0.717***
		(0.553)	(0.473)	(1.522)	(0.033)
Senior high school GPA (Ref: <60%)	60-69%	0.161	0.737	4.055	0.907
		(0.810)	(0.684)	(2.451)	(0.064)
	70-79%	1.683	2.321***	9.022***	0.698***
		(0.943)	(0.807)	(2.750)	(0.057)
	>=80	6.936***	7.152***	21.821***	0.560***
		(1.372)	(1.195)	(3.642)	(0.067)
Was last school attended a university? (Ref: no)	Yes	4.087***	4.509***	10.045***	0.790**
		(0.971)	(0.939)	(2.311)	(0.073)
Did the student plan to go to university? (Ref: no)	Yes			-2.347**	1.279***
				(1.180)	(0.048)
Entering credential (Ref: 2-year diploma)	Certificate 1yr	2.358***	1.691***	-0.287	0.876**
		(0.577)	(0.500)	(1.875)	(0.055)
	Advanced Diploma 3 yr	5.475***	4.410***	7.941***	0.744***
		(0.646)	(0.558)	(1.871)	(0.056)
CPT placement - English (Ref: ELL level 1 or 2)	Below College/ ELL – Level 3	-5.083***	-9.004***	5.720**	1.182**
		(0.886)	(0.878)	(2.574)	(0.087)
	College English/Exempt	4.850***	-5.395***	25.109***	0.685***
		(0.929)	(0.908)	(2.624)	(0.053)
Academic year of entry (Ref: 2007-08)	2008-09	2.560***	1.425**	1.275	1.242***
		(0.702)	(0.662)	(2.486)	(0.085)
	2009-10	0.627	0.538	-0.188	1.387***
		(0.744)	(0.666)	(2.418)	(0.095)
	2010-11	-1.905***	-0.290	-0.290	1.502***
		(0.730)	(0.669)	(2.363)	(0.102)
	2011-12	-4.412***	-1.726**	-6.344***	1.434***
		(0.761)	(0.700)	(2.443)	(0.101)
	2012-13	-4.937***	-2.188***	-6.808***	1.487***
		(0.774)	(0.702)	(2.385)	(0.102)
	2013-14	-7.398***	-3.942***	-9.059***	1.441***
		(0.790)	(0.728)	(2.372)	(0.100)

	2014-15	-5.521***	-3.043***	-5.649**	1.287***
		(0.895)	(0.845)	(2.528)	(0.101)
Term of entry (Ref: winter)	Summer			4.493	1.014
				(4.781)	(0.142)
	Fall			4.632***	0.834***
				(1.653)	(0.043)
Entering program group (Ref: other)	Business				2.970***
					(0.172)
	Technology				5.533***
					(0.367)
Constant		14.710***	28.642***	464.393***	5.587***
		(2.044)	(1.844)	(6.286)	(1.041)
Observations		13,067	12,034	7,621	17,910
R-squared		0.374	0.460	0.391	0.1956

Notes: Robust standard errors in parentheses; ***p<0.01; **p<0.05. Empty cells indicate dropped variables due to insignificance. A linear model was run for the assessment tests (continuous outcomes), whereas a logistic model was run for foundation math placement rate (0/1 outcome). Entering program group was not included for the individual assessment tests.

Overall College Achievement

Multivariable regression models were used to investigate whether high school math background had an independent effect on college academic outcomes (Table 11). As seen with the math assessment scores, higher math averages in high school are associated with higher first-year college math averages, higher overall college GPAs, and higher odds of graduating. A 10% increase in high school math average resulted in a 0.14 increase in first-year math GPA and a 0.03 increase in overall college GPA. Students who took more advanced high school math courses also had much stronger outcomes. For example, students who took grade 12 university preparation math had much stronger college outcomes relative to students who took workplace math: their first-year math GPAs were 1.2 grade points higher, overall GPAs were 0.67 grade points higher and their odds of graduating within one year of the expected date were 2.3 times higher. As well, high school averages had a positive effect on first-year math GPA, overall GPA, and the odds of graduation.

College-level English placement and OSAP receipt (when controlling for neighbourhood income) also had a positive effect on college math average and overall college GPA. Overall, factors associated with a decrease in college math average and overall college GPA included: Canadian citizenship, low income neighbourhood, aspirations for university at college entry, selection of a college business program versus a non-business or technology program, and college entry after 2010-11. Previous university attendance, being male, college entry at 18 years of age versus 19, high income neighbourhood and selection into a technology program were all positively associated with overall college GPA, but not with first-year math grades. The effect of parental education was insignificant.

The logistic regression analysis of the odds of graduating from college showed similar results to those seen in the analysis of college grade outcomes. However, a student's odds of graduating were not affected by being a Canadian citizen, being older (20 to 23 years) at college entry, or having plans for university at college entry.

Table 11. Regression analysis: The effect of high school academic background on Seneca students' first-year college math average, overall college GPA, and graduation rate, Seneca students from an Ontario high school, 2007-2014

VARIABLES	LABELS	College Math Average (4 pt. scale)	Overall College GPA (4 pt. scale)	Graduation rate
High school math course average	Value (20-100%)	0.014***	0.003***	1.006***
		(0.001)	(0.001)	(0.002)
High school average	Value (20-100%)	0.061***	0.071***	1.090***
		(0.002)	(0.001)	(0.003)
High school highest math course taken (Ref: grade 11/12 E)	11 C	0.428***	0.315***	1.362***
		(0.103)	(0.028)	(0.101)
	11 U or M	0.755***	0.479***	1.786***
		(0.099)	(0.029)	(0.141)
	12 C	0.552***	0.334***	1.569***
		(0.094)	(0.026)	(0.110)
	12 U	1.196***	0.673***	2.318***
		(0.095)	(0.028)	(0.173)
Citizenship (Ref: non-Canadian citizen)	Canadian	-0.166***	-0.080***	
		(0.040)	(0.020)	
First language was English (Ref: other)	Yes, English	-0.076***		0.889***
		(0.027)		(0.032)
Age starting college (Ref: <19 years)	19 years	-0.028	-0.061***	0.863***
		(0.029)	(0.014)	(0.032)
	20-<23 years	0.130***	0.064***	0.933
		(0.029)	(0.015)	(0.035)
Student gender (Ref: female)	Male	-0.017	-0.150***	0.727***
		(0.026)	(0.012)	(0.024)
Parental education (Ref: no degree or unknown)	Degree			
Neighbourhood income (Ref: low income)	Mid Income	0.081***	0.074***	1.136***
		(0.028)	(0.013)	(0.041)
	High Income	0.052	0.093***	1.212***
		(0.030)	(0.014)	(0.047)
Was last school attended a university? (Ref: no)	Yes		0.071***	
			(0.024)	
Did the student plan to go to university? (Ref: no)	Yes	-0.072***	-0.052***	
		(0.024)	(0.011)	
Entering credential (Ref: 2-year diploma)	Certificate 1yr	0.289***	0.150***	1.598***
		(0.044)	(0.019)	(0.073)
	Advanced Diploma 3 yr	0.171***	0.141***	1.507***
		(0.052)	(0.023)	(0.090)
CPT placement - English (Ref: ELL level 1 or 2)	Below College/ ELL – Level 3	-0.025	0.147***	1.074
		(0.047)	(0.023)	(0.069)
	College English/Exempt	0.121**	0.369***	1.227***
		(0.049)	(0.024)	(0.081)
Academic year of entry (Ref: 2007/08 – 2010/11)	2011/12 – 2014/15	-0.051**	-0.129***	0.633***
		(0.024)	(0.011)	(0.027)
Term of entry (Ref: winter)	Summer	-0.128	0.071	1.297**
		(0.090)	(0.041)	(0.152)
	Fall	0.059	0.138***	1.272***
		(0.036)	(0.017)	(0.055)
Did the student ever receive OSAP? (Ref: no)	Yes	0.108***	0.074***	1.165***
		(0.024)	(0.011)	(0.036)
Entering program group (Ref: other)	Technology	-0.063	-0.391***	0.801***
		(0.044)	(0.020)	(0.044)
	Business	-0.140***	-0.346***	0.804***

	(0.039)	(0.015)	(0.033)
Constant	-4.175***	-3.806***	0.001***
	(0.162)	(0.071)	(0.000)
Observations	12,867	33,209	20,517
R-squared	0.205	0.296	0.0941

Notes: Robust standard errors in parentheses; ***p<0.01, **p<0.05. Empty cells indicate dropped variables due to insignificance. A linear model was run for overall college GPA and math GPA (continuous outcome), whereas a logistic model was run for graduation rate (0/1 outcome). Graduation rate is the proportion of students who graduated from any program given one extra year. Math GPA excludes foundation math grades.

Math proficiency at college entry and overall college achievement

The previous analysis focussed on high school achievement and college outcomes, and therefore the sample included only those who had attended an Ontario high school and took the OSS curriculum (post-double cohort). The following analysis examines the effect of college math placement testing on college academic outcomes for any Seneca student who completed the testing required for program admission. Programs that require entering students to complete math placement testing are generally those that contain math courses in the curriculum.

Sociodemographics

Students who were older, male, non-citizens, who did not have English as a first language and had a parent with a university degree, had higher averages on all three standardized tests (Table 12). Neighbourhood income was not associated with test score averages.

A similar trend was seen for placement in foundation math, with the exception of gender: females were equally as likely as males to be placed in foundation math (Figure 11).

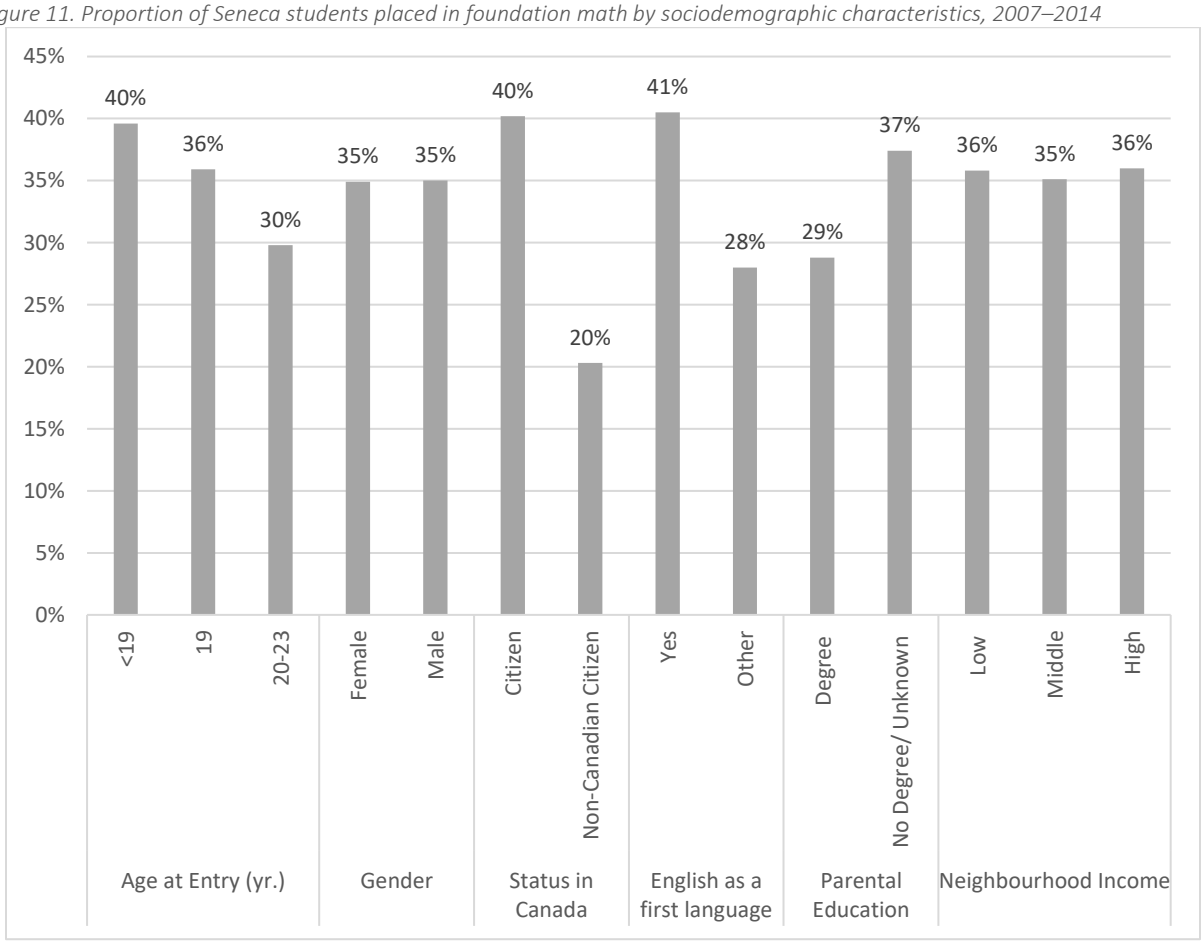
Table 12. Sociodemographic characteristics of Seneca entrants by standardized test scores, 2007–2014

		Arithmetic Scores /120 N=18,953		Algebra Scores /120 N=17,396		CAT-3 Scores N=10,567	
		Mean	95% CI	Mean	95% CI	Mean	95% CI
Age at entry (yr.)	<19	57.9	57.2, 58.6	55.5	54.8, 56.2	598.8	596.9, 600.7
	19	63.1	62.2, 63.9	60.3	59.4, 61.2	600.2	597.9, 602.6
	20- <23	70.7	70.0, 71.4	69.3	68.5, 70.1	607.8	605.8, 609.7
Gender	Female	58.6	58.0, 59.2	60.7	60.0, 61.4	593.8	591.8, 595.7
	Male	69.8	69.1, 70.4	63.2	62.6, 63.8	607.5	606.0, 609.0
	Missing	53.2	43.8, 62.7	46.5	38.1, 54.9	560.7	508.0, 613.5
Status in Canada	Citizen	58.3	57.8, 58.8	53.3	52.9, 53.8	598.1	596.8, 599.5
	Non-Canadian Citizen	80.2	79.4, 81.0	85.0	84.1, 85.9	617.6	615.0, 620.2
	Missing	63.6	60.0, 67.1	60.1	56.3, 63.8	599.7	587.3, 612.1
English as a first language	Yes	58.1	57.5, 58.6	52.0	51.4, 52.5	596.3	594.8, 597.8
	Other	71.8	71.2, 72.5	74.4	73.7, 75.1	611.3	609.4, 613.2
Parental education	Degree	69.2	68.4, 70.1	66.7	65.9, 67.6	614.7	612.6, 616.9
	No Degree/ Unknown	62.3	61.8, 62.9	60.3	59.7, 60.8	597.7	596.3, 599.1
Neighbourhood income	Low	63.3	62.5, 64.0	62.9	62.2, 63.7	599.0	596.9, 601.0
	Middle	64.1	63.4, 64.9	61.6	60.8, 62.3	603.4	601.4, 605.4
	High	63.1	62.3, 64.0	58.2	57.3, 59.0	605.0	602.7, 607.2
	Missing	76.9	74.9, 78.9	79.5	77.4, 81.7	616.6	610.7, 622.5
OSAP recipient	Yes	59.3	58.7, 60.0	57.3	56.6, 57.9	597.6	595.9, 599.3

	No	67.8	67.2, 68.4	65.5	64.8, 66.1	607.4	605.8, 609.1

Note: CAT-3 test scores were converted to a linear scale; CI= Confidence interval

Figure 11. Proportion of Seneca students placed in foundation math by sociodemographic characteristics, 2007–2014



Note: N=24,915

Previous university and plans for university

Students who reported that the last school they attended was university obtained higher scores in each of the standardized tests (Table 13) and were much less likely to be placed in foundation math (14% vs. 37%). Plans for university had little effect on assessment test scores and math placement.

Table 13. Previous university attendance and plans for university among Seneca entrants by standardized test scores and placement in a foundation college math course, 2007–2014

		Accuplacer score (/120)			
		Arithmetic	Algebra	CAT-3 level 19 (Tech)	% placed in foundation math
Previously attended university	No	62.2	59.9	597.5	37.3%
	Yes	83.8	83.0	645.3	14.3%
Plans for university	No	62.9	61.1	599.9	35.6%
	Yes	65.2	62.6	606.3	34.4%

Interaction between language and math placement

Language proficiency and math placement interacted in complex ways, largely because those students who performed well in math were much less likely to have English as a first language. Students with higher test scores in reading comprehension also obtained higher test scores in arithmetic and CAT-3 assessment tests (Table 14). However, algebra scores did not differ greatly by reading comprehension level, except for the highest reading level (99-120) which also produced a slight y higher average algebra score. The rate of placement in foundation math was similar for students in the two lowest levels of reading comprehension, and progressively higher than for students at ech of the two highest levels of reading comprehension.

Table 14. Standardized math test scores and placement in foundational math by reading comprehension test scores of Seneca entrants, 2007–2014

	Accuplacer score (/120)			
	Arithmetic	Algebra	CAT-3 level 19 (Tech)	% placed in foundation math
<51	59.2	64.0	578.0	42.4%
51-77	58.9	57.5	595.2	40.6%
78-98	70.9	63.1	618.1	27.5%
99-120	85.3	70.7	645.2	15.7%
Total	64.0	61.7	602.5	35.5%
n	16,331	15,167	9,800	21,976

However, the analysis revealed a disconnect between math assessment scores and placement in foundation English. English placement at Seneca is primarily determined by a short essay writing test, rather than on reading comprehension. As Table 15 shows, students who placed in the lowest English-language levels (ELL levels 1 & 2) also obtained the highest average arithmetic and algebra scores and were the least likely to be placed in foundation math. Students placed in intermediary level, (ELL level 3 & below college-level English), had the weakest assessment scores.

Table 15. Language placement of Seneca entrants by standardized math test scores and placement in foundational math, 2007–2014

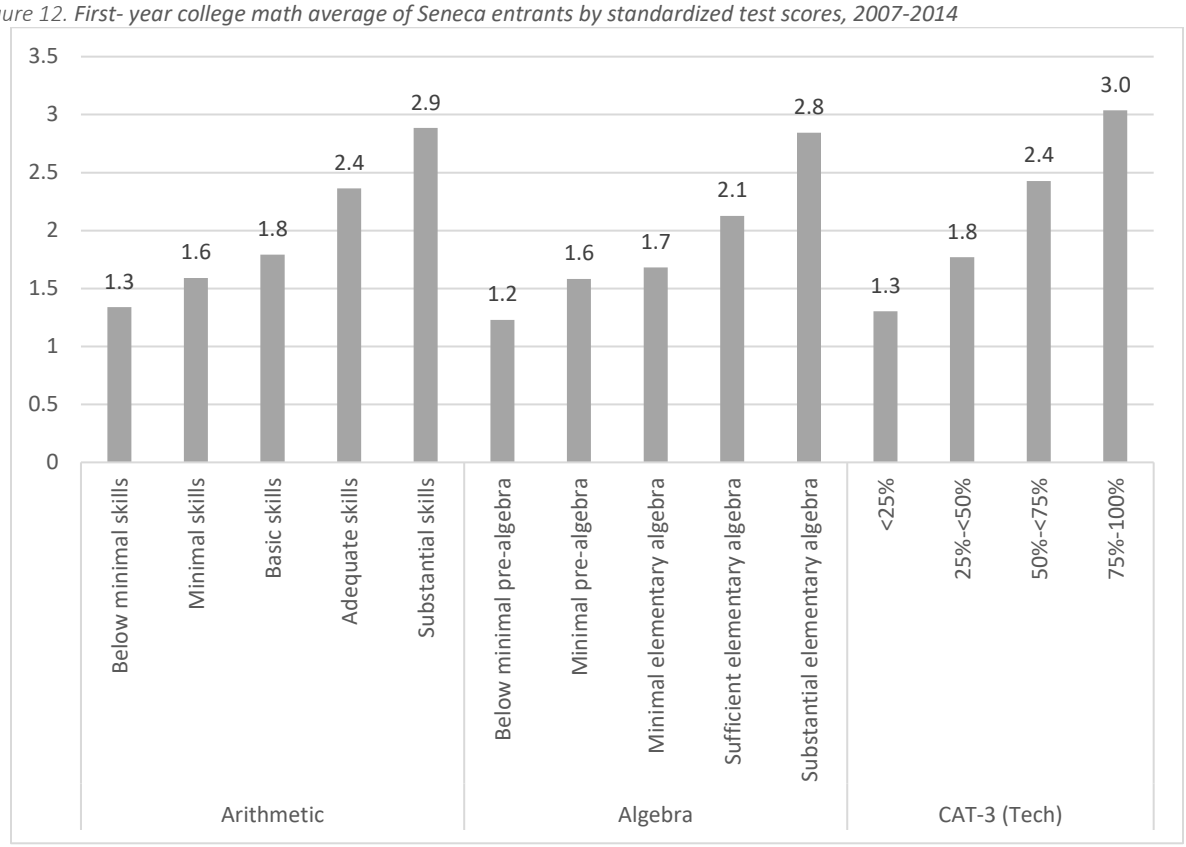
		Accuplacer score (/120)			
		Arithmetic	Algebra	CAT-3 level 19 (Tech)	% placed in foundation math
College English course placement	ELL level 1& 2	76.6	83.5	603.5	25%
	ELL-3 & below College-level English*	55.8	55.1	588.2	45%
	College-level English & exempt	67.8	60.5	615.9	29%
	Total	64.2	62.0	602.7	35%
	n	18,953	17,396	10,567	24,915

Note: *Includes both students who are native English speakers but write below college level English and higher level English language learners

Academic performance

Figures 12 through 18 show the relationship between math assessment test scores and placement in foundation math, and academic outcomes (as measured by grades and graduation rates). Students who entered college with stronger math skills outperformed those with weaker math skills by a large margin. For example: students who had "substantial arithmetic skills" (based on initial assessment testing) had a GPA of 2.5 compared with 1.5 for those who scored at the lowest arithmetic level (Figure 14); and 58% of those with strong arithmetic skills at entry graduated within one year of the expected date compared with only 34% of those at the lowest arithmetic level (Figure 16). Even when students who did not graduate were excluded, an increase in GPA was associated with a higher level of math proficiency (results not shown).

Figure 12. First- year college math average of Seneca entrants by standardized test scores, 2007-2014



Notes: N=13,420 for arithmetic; N=12, 912 for algebra; and N=7, 223 for CAT-3 (engineering/technology students).

Figure 13. First-year college math average of Seneca students and Seneca graduates by math placement, 2007-2014

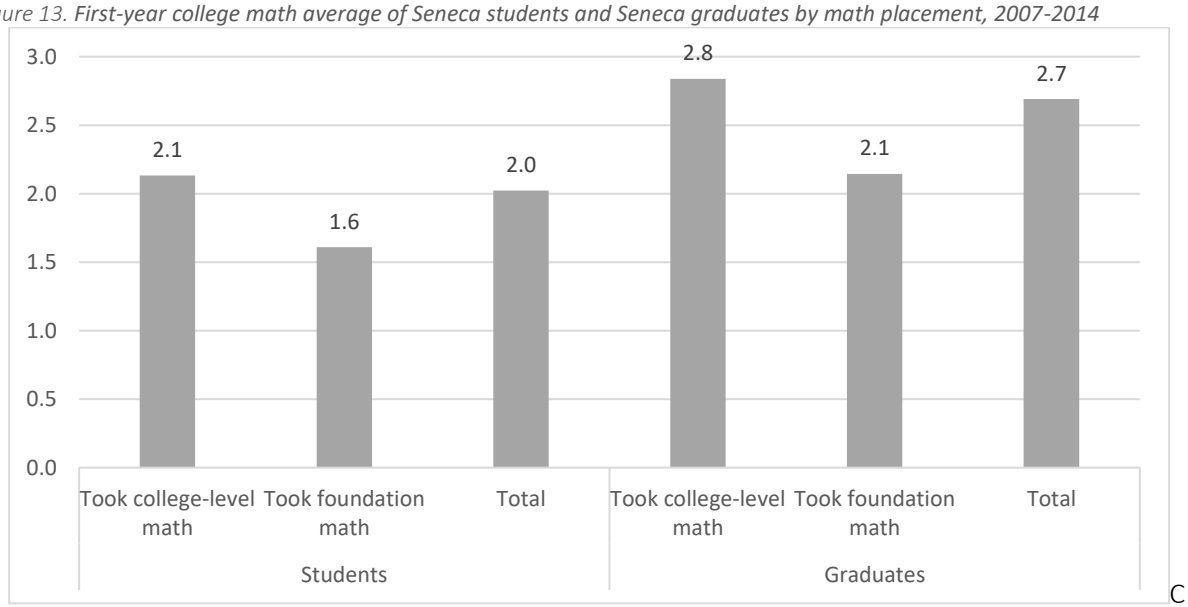


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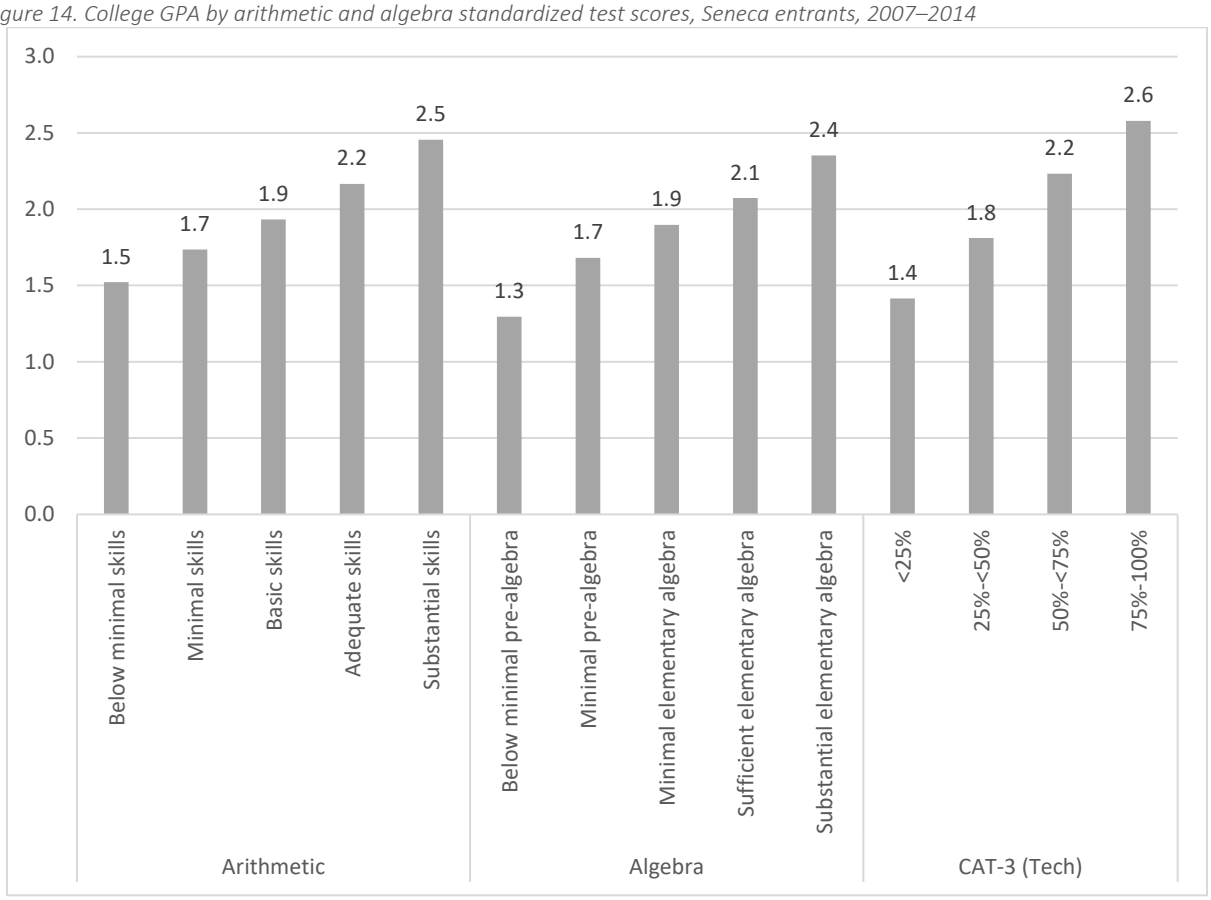
Figure 14. College GPA by arithmetic and algebra standardized test scores, Seneca entrants, 2007–2014



Notes: GPA includes all grades up to first credential. N=18,772 for arithmetic; N=17,217 for algebra; and N=10,465 for CAT-3 (engineering/technology students).

Figure 15. College GPA up to first credential, by math placement, Seneca students and graduates, 2007-2014

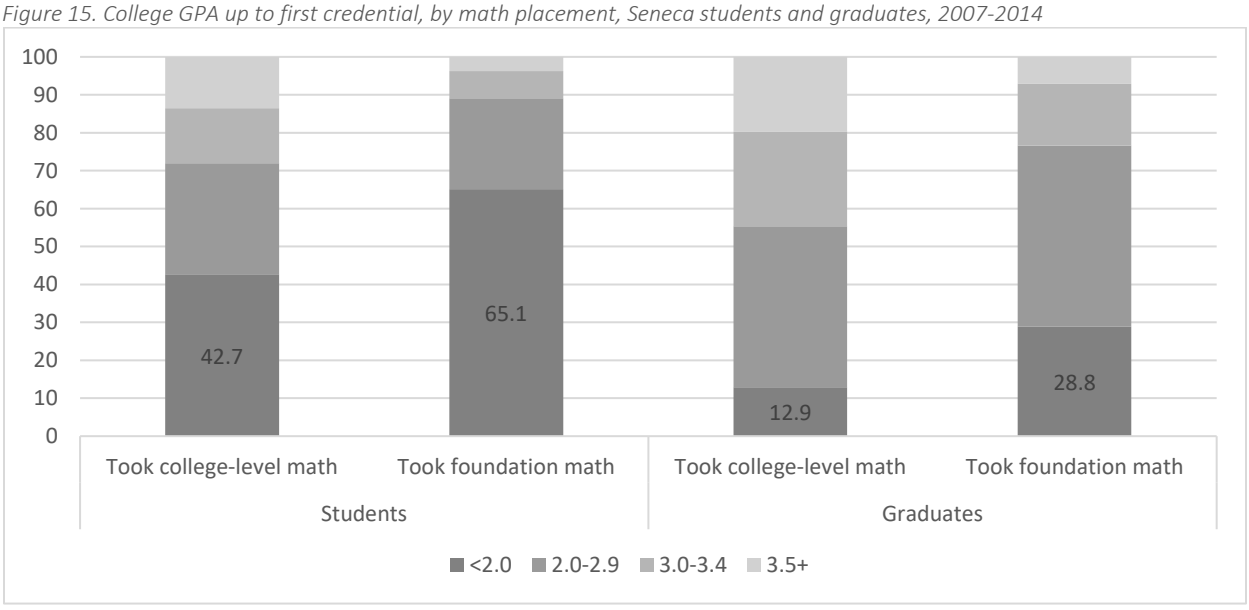


Figure 16. Proportion of students who graduate on time and who graduate within one additional academic year, by arithmetic and algebra proficiency level, Seneca entrants, 2007–2014

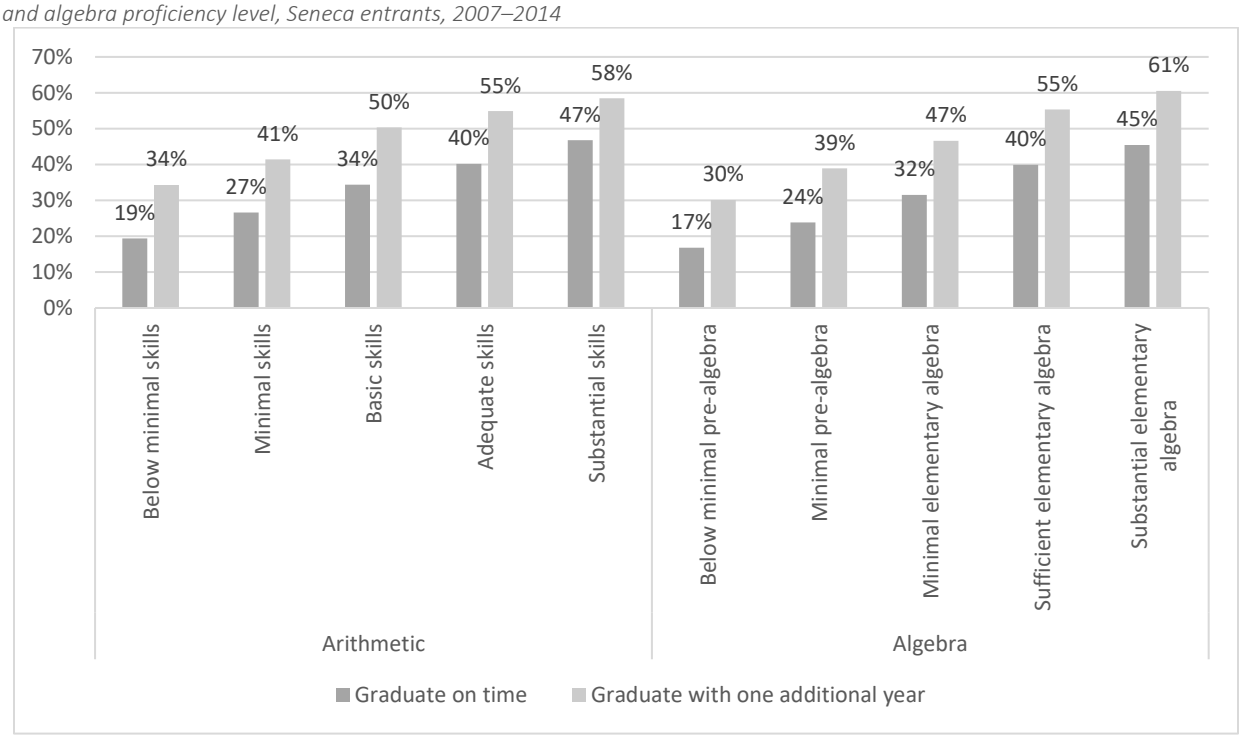


Figure 17. Proportion of students who graduate on time and who graduate within one additional academic year, by CAT-3 test score percentiles, Seneca entrants, 2007–2014

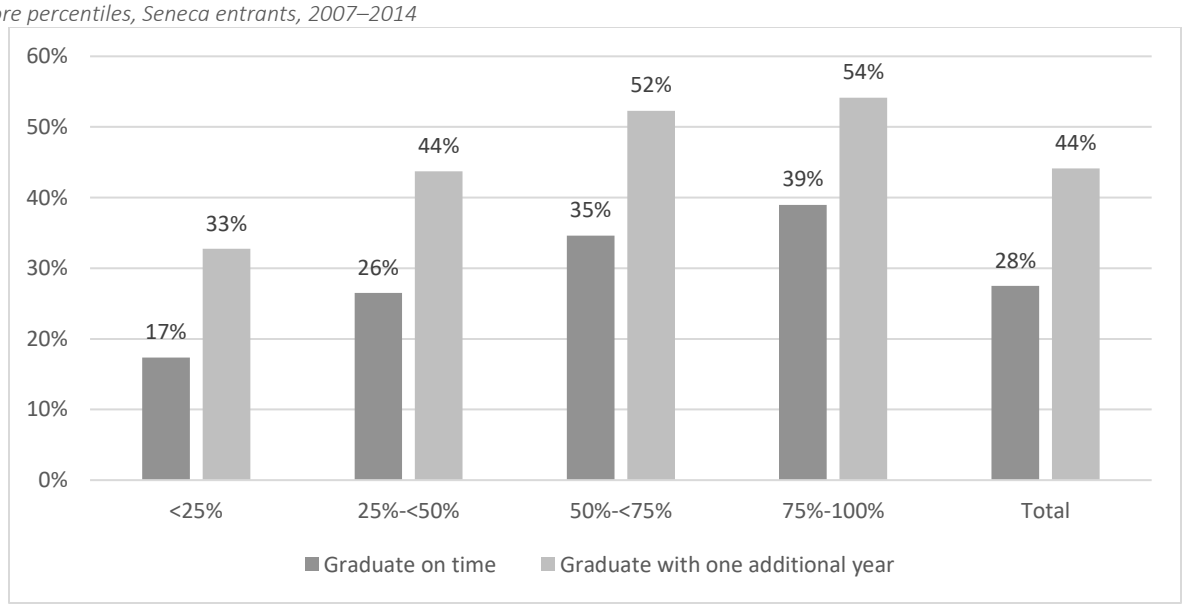
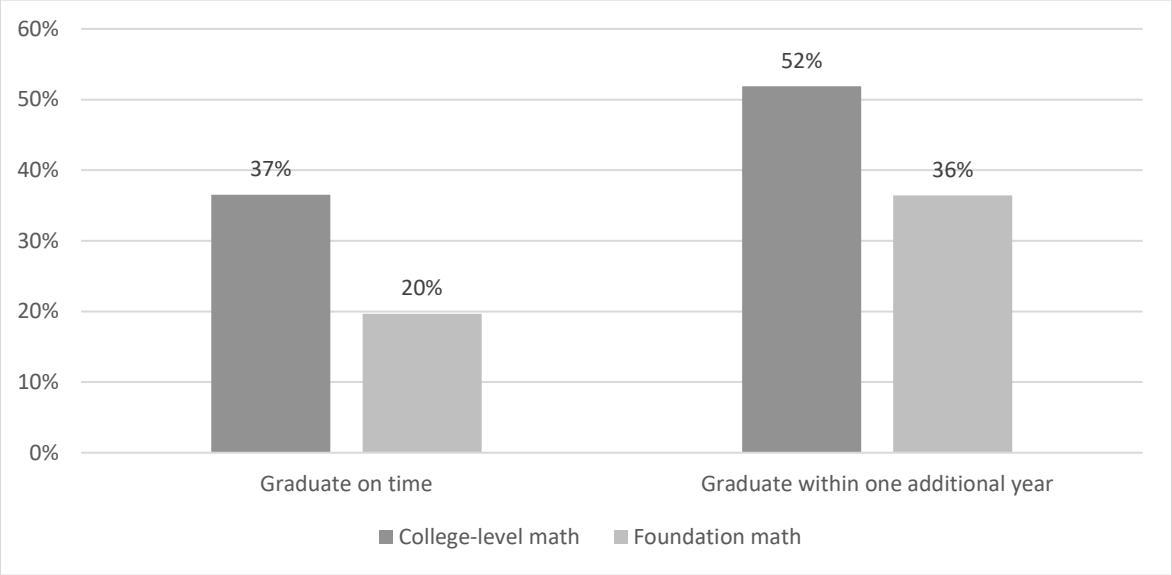


Figure 18. Proportion of students who graduate on time and who graduate within one additional academic year by, college math course placement, Seneca entrants, 2007-2014



Regression models

Tables 16 through 19 show the effect of college math placement test scores (algebra, arithmetic, CAT-3) and placement in foundation math on academic outcomes, controlling for sociodemographic factors, college program selection, and English-language proficiency. Linear regression was used to estimate the effect of math placement test scores on college math average and overall college GPA, whereas logistic regression was used to estimate the effect of college placement testing on the odds of graduating within a year of the expected date.

As in the descriptive results, higher scores in each of the math placement tests are associated with higher first-year math grades, higher overall college GPA, and higher graduation rates. For example, with every 10-point increase in the arithmetic Accuplacer score, there is a 0.14 increase in math GPA, and a 0.09 increase in overall college GPA. Students who were placed in foundation math obtained a first-year math GPA (excluding foundation courses) that was 0.06 lower than for those who were not placed in foundation math, and an overall GPA that was 0.5 lower.

College Math Average

Other factors associated with higher first-year college grades in math included: previous university attendance, OSAP receipt, being female, entering college under 19 years of age, not having a parent with a degree (or unknown), and being placed above the ELL level 1/2 for language.

Similar overall associations were observed for technology entrants (Table 18). However, in comparison with the algebra and arithmetic models, the CAT-3 model demonstrated a decrease in first-year college math average among students whose first language was English, but language placement, parental education, and OSAP receipt had no effect.

Overall College GPA

An increase in overall college GPA was observed among students who spoke English as a first language, came from a higher income neighbourhood, last attended a university, were placed in ELL level 3 or in college-level English (i.e., above ELL levels 1/2) and received OSAP. Overall college GPAs were lower among students who were Canadian citizens, entered college after 18 years of age, were male, aspired to attend university, and entered either a technology or business program.

The results were similar for students who completed the CAT-3 test (technology entrants). However, unlike the arithmetic and algebra regression models, the CAT-3 model showed that neighbourhood income had no effect on overall GPA within this group.

Graduation

As previously mentioned, higher math assessment results, math GPA and overall GPA increased the likelihood of graduation from college. Results of the multivariable logistic regression model show that students are more likely to graduate if they are from a higher income neighbourhood, last attended a university, entered an advanced college program (one-year graduate certificate or a three-year diploma), scored above ELL 1/2 in language placement testing, and received OSAP. The likelihood of a student graduating from college decreased if they were Canadian citizens, older than 18 at college entry, male, and planning to attend university after college.

CAT-3 scores affected the odds of graduation, with very similar associations. However, neighbourhood income was not significantly associated with graduation outcomes. English as a first language lowered the odds of graduating.

Table 16. Regression analysis: The effect of arithmetic test scores on first-year college math average, overall college GPA and graduation rates, Seneca entrants, 2007-2014

VARIABLES	LABELS	College Math Average (4 pt. scale)	Overall College GPA (4 pt. scale)	Graduation Rate
Arithmetic scores	120 point scale	0.014***	0.009***	1.010***
		(0.000)	(0.000)	(0.001)
Citizenship (Ref: non-Canadian citizen)	Canadian	-0.363***	-0.243***	0.645***
		(0.034)	(0.024)	(0.037)
First language was English (Ref: other)	Yes, English			
Age starting college (Ref: <19 years)	19 years	-0.178***	-0.233***	0.667***
		(0.033)	(0.021)	(0.034)
	20-23 years	-0.088***	-0.200***	0.665***
		(0.032)	(0.021)	(0.033)
Gender (Ref: female)	Male	-0.426***	-0.510***	0.506***
		(0.026)	(0.017)	(0.021)
Parental education (Ref: parent has no degree/unknown)	Parent has a degree	-0.088***		
		(0.028)		
Neighbourhood income (Ref: low Income)	Mid Income	0.087***	0.066***	1.154***
		(0.029)	(0.019)	(0.054)
	High Income	0.043	0.083***	1.173***
		(0.033)	(0.022)	(0.060)
Was last school attended a university? (Ref: no)	Yes	0.365***	0.372***	1.658***
		(0.043)	(0.031)	(0.127)
Did the student plan to go to university? (Ref: no)	Yes	-0.124***	-0.154***	0.855***
		(0.026)	(0.017)	(0.034)
Entering credential (Ref: 2-year diploma)	Certificate 1 yr	0.353***	0.181***	2.019***
		(0.047)	(0.027)	(0.113)
	Advanced Diploma 3 yr	0.377***	0.229***	2.063***
		(0.057)	(0.035)	(0.131)
CPT placement - English (Ref: ELL level 1 or 2)	Below College/ ELL – Level 3	0.133***	0.279***	1.237***
		(0.039)	(0.027)	(0.082)
	College English/Exempt	0.226***	0.523***	1.486***
		(0.041)	(0.028)	(0.102)
Academic year of entry (Ref: 2007/08 – 2010/11)	2011/12 – 2014/15	0.064**		0.734***
		(0.026)		(0.043)
Term of entry (Ref: winter)	Summer		0.046	1.181
			(0.045)	(0.135)
	Fall		0.122***	1.233***
			(0.021)	(0.061)
Did the student ever receive OSAP? (Ref: no)	Yes	0.131***	0.088***	1.240***
		(0.026)	(0.017)	(0.050)
Entering program group (Ref: other)	Technology	-0.139	-0.309***	
		(0.112)	(0.079)	
	Business	-0.166***	-0.083***	
		(0.042)	(0.024)	
Constant		1.041***	1.287***	0.374***
		(0.066)	(0.045)	(0.041)
Observations		12,435	17,553	11,816
R-squared		0.129	0.148	0.067

Notes: Robust standard errors in parentheses; ***p<0.01, **p<0.05. Empty cells indicate dropped variables due to insignificance. A linear model was run for overall college GPA and math GPA (continuous outcome), whereas a logistic model was run for graduation rate (0/1 outcome). Graduation rate is the proportion of students who graduated from any program given one extra year. Math GPA excludes foundation math grades.

Table 17. Regression analysis: The effect of algebra test scores on first-year college math average, overall college GPA and graduation rates, Seneca entrants, 2007-2014

VARIABLES	LABELS	College Math Average (4 pt. scale)	Overall College GPA (4 pt. scale)	Graduation
Algebra scores	120 point scale	0.015***	0.010***	1.012***
		(0.001)	(0.000)	(0.001)
Citizenship (Ref: non-Canadian citizen)	Canadian	-0.293***	-0.212***	0.697***
		(0.035)	(0.026)	(0.042)
First language was English (Ref: other)	Yes, English		0.075***	
			(0.020)	
Age starting college (Ref: <19 years)	19 years	-0.165***	-0.223***	0.678***
		(0.033)	(0.022)	(0.036)
	20-23 years	-0.071**	-0.183***	0.677***
		(0.032)	(0.022)	(0.036)
Gender (Ref: female)	Male	-0.286***	-0.409***	0.561***
		(0.026)	(0.018)	(0.023)
Parental education (Ref: parent has no degree/unknown)	Degree	-0.096***		
		(0.029)		
Neighbourhood income (Ref: low Income)	Mid Income	0.084***	0.067***	1.142***
		(0.030)	(0.020)	(0.056)
	High Income	0.060	0.095***	1.168***
		(0.033)	(0.022)	(0.062)
Was last school attended a university? (Ref: no)	Yes	0.289***	0.312***	1.528***
		(0.043)	(0.033)	(0.122)
Plans for university at entry (Ref: no)	Yes	-0.130***	-0.122***	0.875***
		(0.026)	(0.018)	(0.037)
Entering credential (Ref: 2-year diploma)	Certificate 1 yr	0.358***	0.120***	1.914***
		(0.049)	(0.028)	(0.112)
	Advanced Diploma 3 yr	0.401***	0.212***	2.013***
		(0.059)	(0.037)	(0.129)
CPT placement - English (Ref: ELL level 1 or 2)	Below College/ ELL – Level 3	0.217***	0.307***	1.323***
		(0.040)	(0.029)	(0.092)
	College English/Exempt	0.387***	0.592***	1.696***
		(0.041)	(0.030)	(0.122)
Academic year of entry (Ref: 2007/08 –2010/11)	2011/12 – 2014/15			0.724***
				(0.045)
Term of entry (Ref: winter)	Summer		0.025	1.198
			(0.047)	(0.142)
	Fall		0.119***	1.254***
			(0.022)	(0.065)
Did the student ever receive OSAP? (Ref: no)	Yes	0.124***	0.093***	1.276***
		(0.027)	(0.018)	(0.055)
Entering program group (Ref: other)	Technology	-0.252**	-0.345***	
		(0.115)	(0.081)	
	Business	-0.212***	-0.084***	
		(0.044)	(0.027)	
Constant		0.879***	1.075***	0.283***
		(0.069)	(0.049)	(0.034)
Observations		11,962	16,080	10,779
R-squared		0.125	0.147	0.0692

Notes: Robust standard errors in parentheses; ***p<0.01, **p<0.05. Empty cells indicate dropped variables due to insignificance. A linear model was run for overall college GPA and math GPA (continuous outcome), whereas a logistic model was run for graduation rate (0/1 outcome). Graduation rate is the proportion of students who graduated from any program given one extra year. Math GPA excludes foundation math grades.

Table 18. Regression analysis: The effect of CAT-3 standardized test scores on first-year college math average, overall college GPA and graduation within one additional academic year, Seneca entrants, 2007-2014

VARIABLES	LABELS	College Math Average (4 pt. scale)	Overall College GPA (4 pt. scale)	Graduation
CAT-3 Scores		0.009***	0.006***	1.005***
		(0.000)	(0.000)	(0.001)
Citizenship (Ref: non-Canadian citizen)	Canadian	-0.455***	-0.363***	0.595***
		(0.041)	(0.029)	(0.047)
First language was English (Ref: other)	Yes, English	-0.082**		0.849**
		(0.036)		(0.055)
Age starting college (Ref: <19 years)	19 years	-0.128***	-0.163***	0.764***
		(0.042)	(0.028)	(0.055)
	20-<23 years	-0.062	-0.090***	0.745***
		(0.041)	(0.027)	(0.052)
Gender (Ref: female)	Male	-0.293***	-0.482***	0.553***
		(0.034)	(0.022)	(0.033)
Parental education (Ref: parent has no degree/unknown)	Parent has a BA			
Neighbourhood income (Ref: low income)	Mid Income			
	High Income			
Was last school attended a university? (Ref: no)	Yes	0.455***	0.413***	1.534***
		(0.051)	(0.036)	(0.148)
Plans for university at entry (Ref: no)	Yes	-0.191***	-0.131***	0.741***
		(0.032)	(0.022)	(0.043)
Entering credential (Ref: 2-year diploma)	Certificate 1yr		0.048	1.520***
			(0.033)	(0.122)
	Advanced Diploma 3 yr		-0.061	1.409***
			(0.033)	(0.122)
CPT placement - English (Ref: ELL level 1 or 2)	Below College/ ELL – Level 3		0.185***	1.279***
			(0.035)	(0.122)
	College English/Exempt		0.424***	1.579***
			(0.037)	(0.165)
Academic year of entry (Ref: 2007/08 –2010/11)	2011/12 – 2014/15	0.160***	0.097***	0.823**
		(0.032)	(0.021)	(0.068)
Term of entry (Ref: winter)	Summer	-0.103	-0.128**	0.975
		(0.095)	(0.062)	(0.179)
	Fall	0.073	0.163***	1.260***
		(0.042)	(0.027)	(0.086)
Did the student ever receive OSAP? (Ref: no)	Yes		0.049**	1.195***
			(0.021)	(0.067)
Constant		-2.953***	-1.340***	0.062***
		(0.179)	(0.119)	(0.020)
Observations		7,129	10,332	5,861
R-squared		0.194	0.201	0.053

Notes: Robust standard errors in parentheses; ***p<0.01, **p<0.05. Empty cells indicate dropped variables due to insignificance. A linear model was run for overall college GPA and math GPA (continuous outcome), whereas a logistic model was run for graduation rate (0/1 outcome). Graduation rate is the proportion of students who graduated from any program given one extra year. Math GPA excludes foundation math grades.

Table 19. Regression analysis: The effect of foundation math placement on first-year college math average, overall college GPA and graduation within one additional academic year, Seneca entrants, 2007-2014

VARIABLES	LABELS	College Math Average (4 pt. scale)	Overall College GPA (4 pt. scale)	Graduation
Did the student take remedial college math? (Ref: no)	Yes	-0.061***	-0.495***	0.577***
		(0.004)	(0.015)	(0.022)
Citizenship (Ref: non-Canadian citizen)	Canadian	-0.084***	-0.351***	0.630***
		(0.005)	(0.020)	(0.033)
First language was English (Ref: other)	Yes, English	-0.022***		0.875***
		(0.004)		(0.036)
Age starting college (Ref: <19 years)	19 years	-0.022***	-0.184***	0.733***
		(0.004)	(0.018)	(0.033)
	20-<23 years	-0.007	-0.129***	0.725***
		(0.004)	(0.018)	(0.033)
Student gender (Ref: female)	Male	-0.044***	-0.424***	0.560***
		(0.004)	(0.015)	(0.021)
Parental education (Ref: no degree/unknown)	Degree		0.032	
			(0.017)	
Neighbourhood income (Ref: low income)	Mid Income	0.017***	0.073***	1.165***
		(0.004)	(0.017)	(0.049)
	High Income	0.010**	0.080***	1.175***
		(0.004)	(0.019)	(0.054)
Was last school attended a university? (Ref: no)	Yes	0.087***	0.477***	1.634***
		(0.006)	(0.026)	(0.108)
Plans to go to university at entry (Ref: no)	Yes	-0.018***	-0.128***	0.857***
		(0.003)	(0.015)	(0.031)
Entering credential (Ref: 2-year diploma)	Certificate 1yr	0.043***	0.145***	1.898***
		(0.006)	(0.026)	(0.112)
	Advanced Diploma 3 yr	0.045***	0.183***	1.891***
		(0.008)	(0.031)	(0.143)
CPT placement - English (Ref: ELL level 1 or 2)	Below College/ ELL – Level 3	0.009	0.237***	1.238***
		(0.006)	(0.024)	(0.075)
	College English/Exempt	0.047***	0.528***	1.617***
		(0.006)	(0.025)	(0.106)
Academic year of entry (Ref: 2007-08 – 2010-11)	2011-12 - 2014-15	0.011***		0.716***
		(0.003)		(0.039)
Term of entry (Ref: winter)	Summer	-0.004	0.021	1.128
		(0.009)	(0.042)	(0.123)
	Fall	0.011**	0.119***	1.216***
		(0.004)	(0.019)	(0.055)
Did the student ever receive OSAP? (Ref: no)	Yes	0.009**	0.071***	1.232***
		(0.004)	(0.015)	(0.045)
Entering program group (Ref: other)	Technology	0.045***	0.122***	1.187***
		(0.006)	(0.026)	(0.076)
	Business	-0.004	0.038	1.158***
		(0.006)	(0.022)	(0.064)
Constant	Constant	0.609***	1.992***	0.835
		(0.009)	(0.038)	(0.077)
Observations	Observations	17,680	23,112	14,335
R-squared	R-squared	0.088	0.146	0.0595

Notes: Robust standard errors in parentheses; ***p<0.01, **p<0.05. Empty cells indicate dropped variables due to insignificance. A linear model was run for overall college GPA and math GPA (continuous outcome), whereas a logistic model was run for graduation rate (0/1 outcome). Graduation rate is the proportion of students who graduated from any program given one extra year. Math GPA excludes foundation math grades.

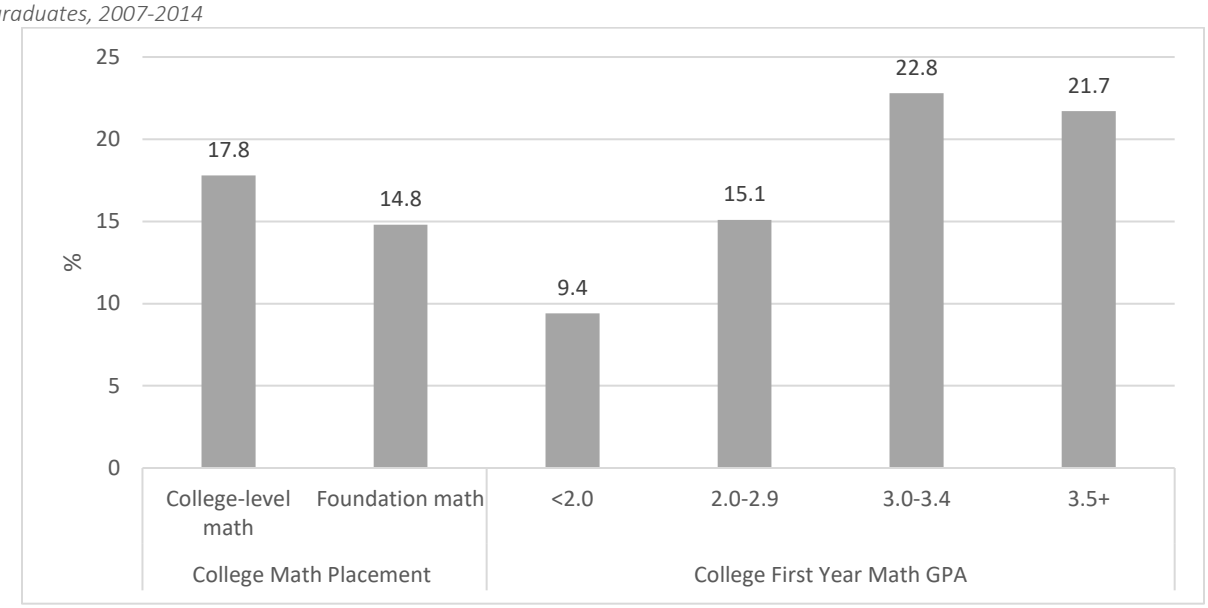
Graduate Outcomes: further education and the labour market

The study investigated whether math skills at college entry, as determined by initial placement in college math and first-year math average, had a bearing on graduates' transfer to university and labour market outcomes.

Transfer to university

College graduates who were placed in foundation math were less likely to transfer to university than those who were placed college-level math (14.8% vs. 17.8%). Rates of transfer to university were higher for students who had achieved higher grades in first-year math, particularly for those with a college math GPA over 3.0 (Figure 19.).

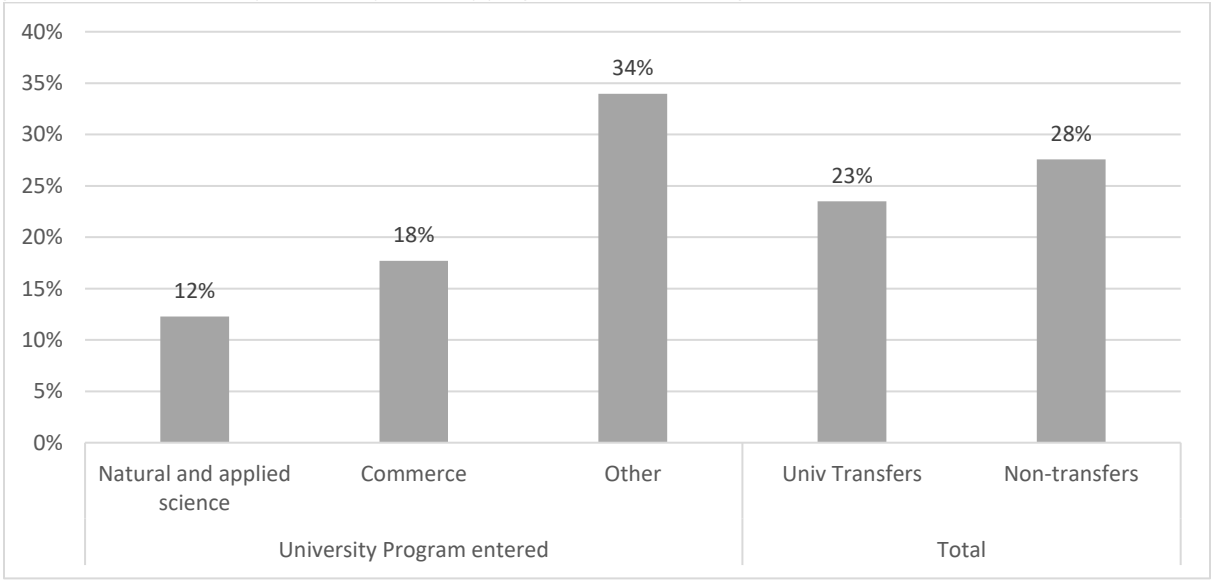
Figure 19. Proportion of graduates who transfer to university by math placement at college entry and college math grades, Seneca graduates, 2007-2014



The study also looked at whether math proficiency at college entry was associated with initial field of study among graduates who transferred to university. Figure 20 shows that college graduates who entered science and engineering fields at university had a strong first-year college math average (GPA 3.33) and a lower odds (12%) of being placed in foundation college math (Figure 21). Graduates who entered commerce fields at university had intermediate math proficiency in college, whereas those who entered "other" fields, primarily social sciences and the humanities, had lower college math averages; more than two-thirds (34%) of this group were placed in foundation college math.

Figure 20. First-year college math GPA by university program entered, Seneca graduates, 2007-2014

Figure 21. Foundation math placement by university program entered, Seneca graduates, 2007-2014



Labour market outcomes

Results from the GSS include information about employment status for graduates not attending full-time school in a reference week, six months after graduating. The descriptive results, shown in Figures 22 and 23, suggest that graduates with enhanced math skills at college entry obtain jobs that are more aligned with their credential.

Figure 22 shows that graduates who were placed in a foundation math course were slightly more likely to be employed than those who were not (79% vs 77%). However, they were much more likely to be overqualified, i.e., in a job not requiring a postsecondary credential (57% vs. 42%), and less likely to have

a job related to their field of study (49% vs 61%). For graduates of two- and three-year diploma programs, the likelihood of having a job related to their field of study was higher if they had been placed in college-level math at entry; this was particularly the case for graduates of two-year programs (Figure 23). Graduation from a one-year certificate program had little effect on job relatedness, which is not surprising; 73% of one-year certificate programs are preparatory and not tied to an occupational field.

Figure 22. Employment status for graduates in labour force by math placement at college entry, 6 months after graduation, 2007-2014

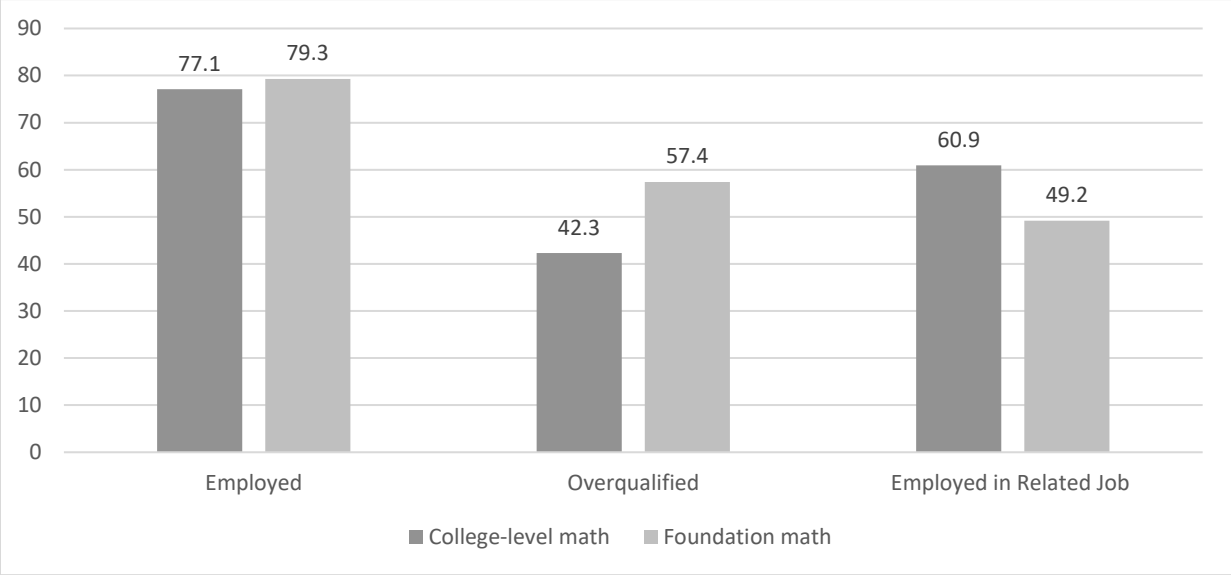
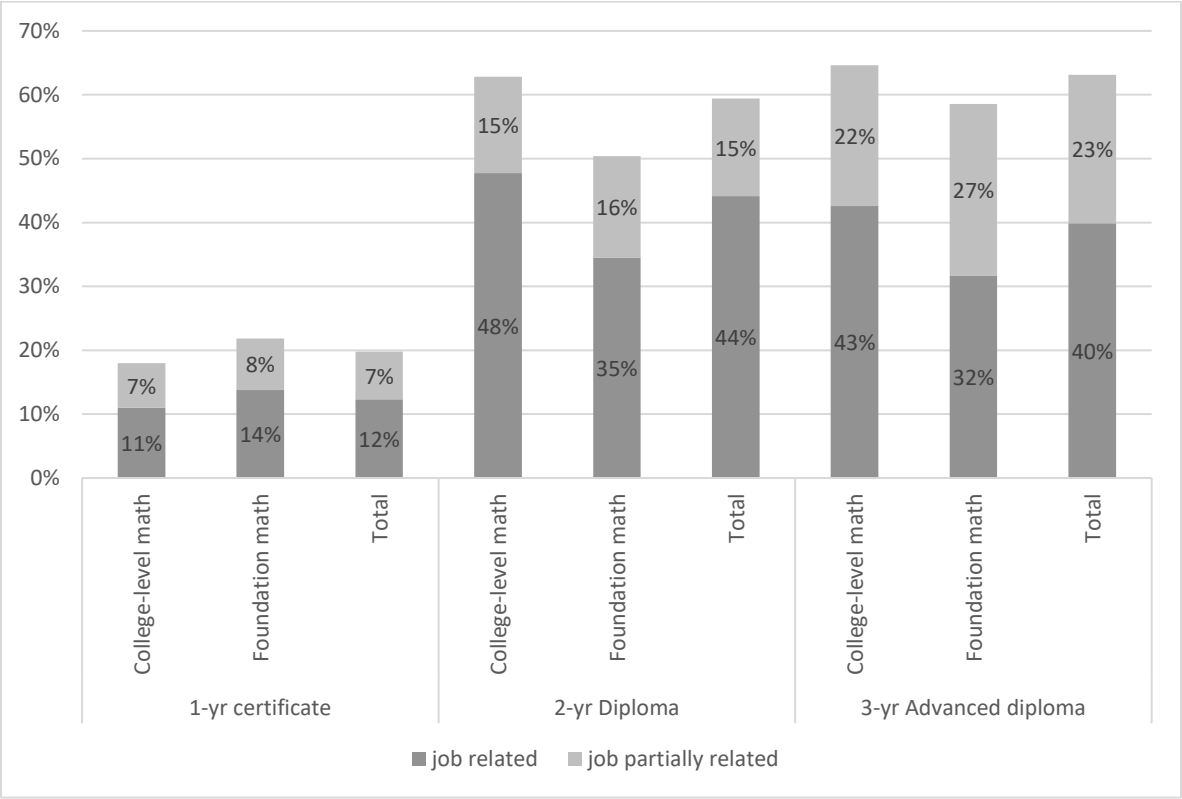


Figure 23. Proportion of graduates employed in jobs related to their field of study by math placement at college entry and credential, 6 months after graduation, 2007-2014

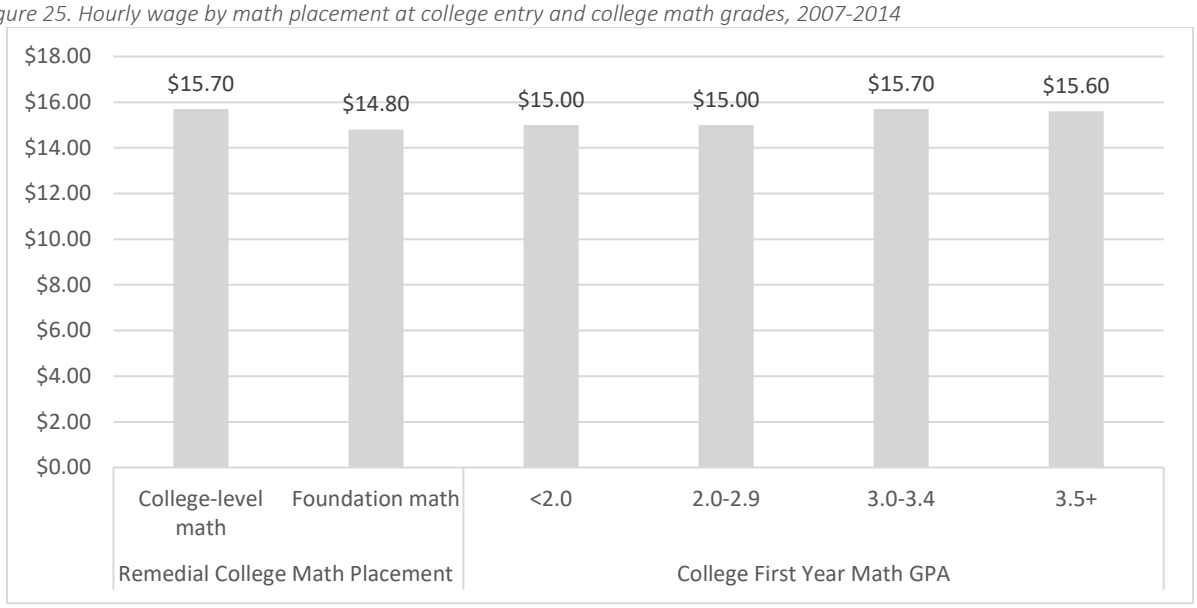


Similar trends are shown for employment status by first-year college math grades (Figure 24). Overall, the proportion of graduates employed differed little across math grades. However, graduates with the highest math GPAs (3.5+) in first year were much less likely to be overqualified and more likely to be employed in a job related to their field of study than those who achieved lower math grades.

Figure 24. Employment status by first-year college math GPA, 6 months after graduation, 2007-2014

Math placement and first-year math grades had a slight effect on graduates' hourly wage. The hourly wage was 6% lower for graduates who were placed in foundation math compared with graduates with college-level math proficiency at entry (Figure 25). Graduates with a first-year math GPA of 3.0+ earned a slightly higher hourly wage compared with graduates with a lower first-year math GPA.

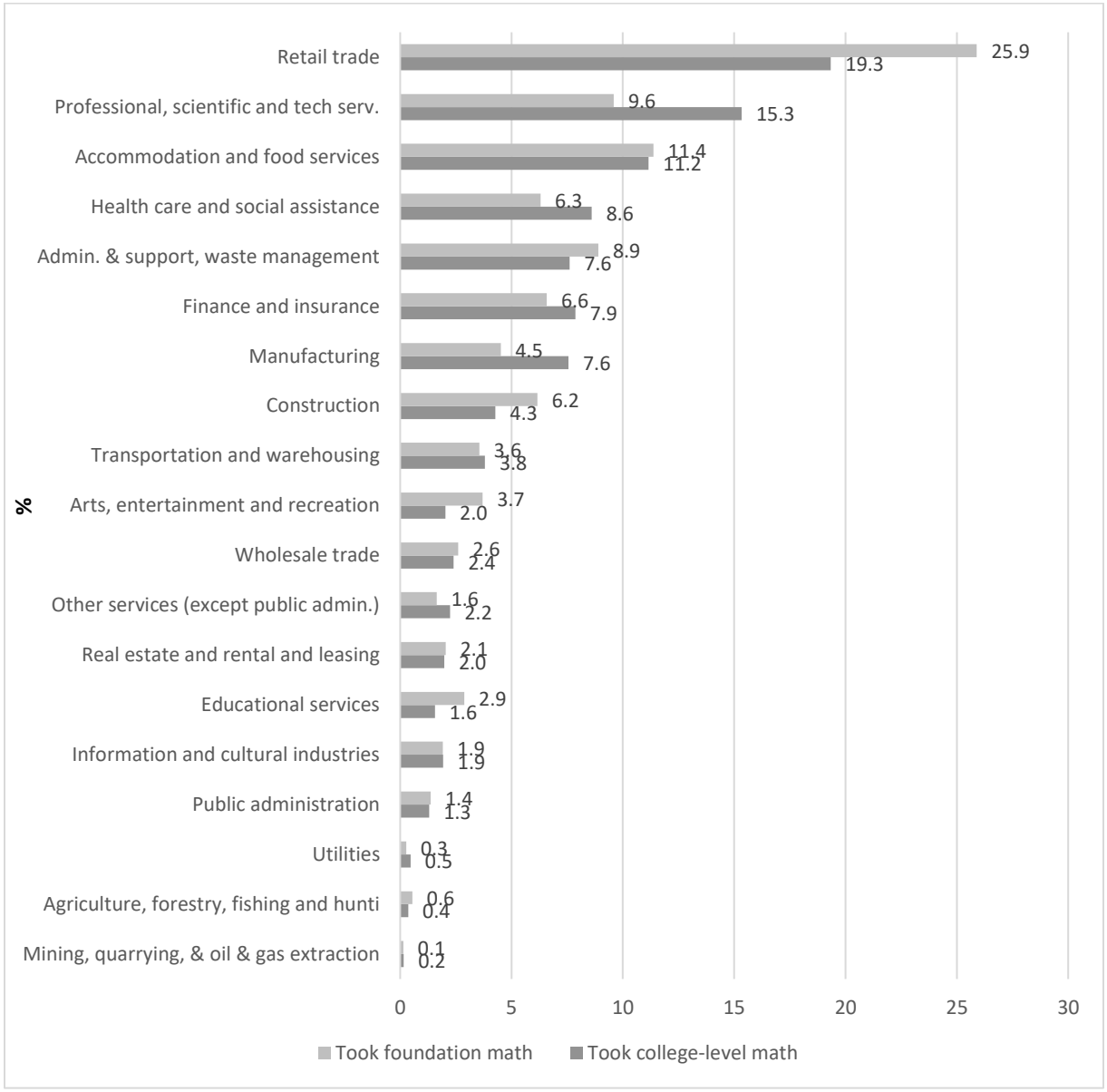
Figure 25. Hourly wage by math placement at college entry and college math grades, 2007-2014



Note: Adjusted for Ontario's CPI and converted to 2014 dollars.

Figure 26 shows the relationship between math placement at college entry and industry of employment. Graduates who did not require foundation math at college entry were more likely to be in sectors that required more skills, such as professional services, finance and manufacturing, and less likely to be in the retail industry.

Figure 26. Industry of employment (based on NAIC [22]) by math placement at college entry, 6 months after graduation, 2007-2014 graduates



Regression results

Logistic and linear regression results show how first-year college math average and placement in foundation math influenced a range of outcomes six months after graduation, including: transfer to university, employment rate, job relatedness to field of study, overqualification and hourly wage.

[22] North American Industry Classification System

Transfer to University

Table 20 presents two regression models that show the effect of first-year college math average[23] (model 1) and placement in foundation math (model 2) on graduates' transfer to university.

As shown previously in the descriptive results and in model 1, the odds of transferring to university become higher with increases in college math average. Whereas the descriptive results show a lower transfer rate to university for students placed in foundation math, model 2 shows no significance. This discrepancy is likely because the odds of transferring to university are higher for students with higher overall college GPAs, who are also less likely to be placed in foundation math.

Plans for transfer to university at college entry are very strong in both regression models. Students who indicated they planned to attend were almost 6 times as likely to transfer as those who did not. As well, graduates from three-year (advanced) diploma programs had higher rates of transfer than two-year diploma graduates. In model 1, (but not in model 2) younger students (under 22 years old) had a higher odds of transferring to university compared with students ages 22 and older. In both models, gender had no significant effect on the odds of transferring to university.

In both models, graduates of technology or business programs were less likely to transfer to university compared with graduates of non-technology programs that required math.

[23] Excluding foundation math courses.

Table 20. Regression analysis: The effect of first-year college math average (excluding foundation math courses) and placement in foundation math on transfer to university among Seneca graduates, 2007-2014

VARIABLES	LABELS	Transfer to University (College math, Model 1)	Transfer to University (Math placement, Model 2)
Foundation math placement (Ref: no)	Yes	---	1.218
			(0.125)
College math GPA	4 pt. scale	1.445***	---
		(0.063)	
Citizenship (Ref: non-Canadian citizen)	Canadian		
First language was English (Ref: other)	Yes, English		
Age at graduation (Ref: <22 years)	≥22 years	0.770**	0.911
		(0.079)	(0.088)
Gender (Ref: female)	Male	1.049	1.157
		(0.097)	(0.103)
Parental education (Ref: parent has no degree/unknown)	Degree		
Did the student ever receive OSAP? (Ref: no)	Yes		
Seneca graduate GPA quartile (Ref: 0-24th percentile)	25th-49th Percentile	---	1.867***
			(0.242)
	50th-74th Percentile	---	2.751***
			(0.361)
	75th-100th Percentile	---	3.736***
			(0.504)
Was last school attended a university? (Ref: no)	Yes		
Did the student plan to go to university? (Ref: no)	Yes	5.533***	6.083***
		(0.579)	(0.612)
Graduated program group (Ref: other)	Technology	0.280***	0.383***
		(0.047)	(0.059)
	Business	0.473***	0.632***
		(0.066)	(0.077)
Graduated credential (Ref: 2-year diploma)	Certificate 1 yr	0.349***	0.552***
		(0.066)	(0.088)
	Advanced Diploma 3 yr	2.202***	1.856***
		(0.237)	(0.203)
English placement (Ref: college English – level 4)	ELL – Level 1 or 2		
	Below College-Level/ELL – Level 3		
Academic year of graduation (Ref: 2008-2011)	2012-2014	0.686***	0.715***
		(0.063)	(0.062)
Term of graduation (Ref: fall)	Summer	4.154***	3.837***
		(0.767)	(0.687)
	Winter	4.237***	5.010***
		(0.729)	(0.837)
Constant		0.016***	0.012***
		(0.004)	(0.003)
Observations		4,171	4,847
R-squared		0.186	0.1938

Notes: Robust standard errors in parentheses; ***p<0.01, **p<0.05. Empty cells indicate dropped variables due to insignificance; --- indicates variables not included. A logistic model was run for all models (0/1 outcome). College math average excluded foundation math courses.

Employment Outcomes: by first-year college math average

Employment rates. Results for the effect of first-year college math average on the odds of employment are presented in Table 21. Although the descriptive results showed no difference in employment by college math average, the regression results showed that when controlling for selected factors, graduates who had higher college math averages in first year had a higher odds of being employed. Overall, the likelihood of being employed was higher for graduates who were Canadian citizens, spoke English as a first language and had above ELL 1/2 in language course placement. The odds of being employed did not differ by age or gender when controlling for all selected covariates.

Job relatedness and overqualification. As also shown in the descriptive results, an increase in first-year college math average is associated with an increased likelihood of job relatedness and a decreased likelihood of overqualification (Table 21). Age at graduation, parental education, and first language had no effect on whether a graduate was employed in a field related to their program of study or whether they were overqualified. However, graduates who had Canadian citizenship as students, who received OSAP during their college studies and who graduated from a one-year (preparatory) certificate program (compared with a two-year diploma program) were less likely to have a job related to their field of study and more likely to be overqualified. Graduates with previous university attendance were less likely to be overqualified, whereas male graduates were more likely to report being overqualified. English-language placement at below college-level English, but at an intermediate level, was also associated with overqualification.

Table 21. Regression analysis: The effect of first-year college math average on employment, job relatedness, and overqualification, Seneca graduates six months after graduation, 2007-2014

VARIABLES	LABELS	Employment	Related Job	Overqualified
College math average	4 pt. scale	1.117***	1.207***	0.815***
		(0.046)	(0.049)	(0.039)
Citizenship (Ref: non-Canadian citizen)	Canadian	1.544***	0.795**	1.810***
		(0.184)	(0.089)	(0.242)
First language was English (Ref: other)	Yes, English	1.426***		
		(0.166)		
Age at graduation (Ref: <22 years)	≥22 years	1.211	1.149	0.913
		(0.149)	(0.137)	(0.124)
Student gender (Ref: female)	Male	1.084	0.892	1.493***
		(0.105)	(0.090)	(0.172)
Parental education (Ref: no degree/unknown)	Degree			
Did the student ever receive OSAP? (Ref: no)	Yes		0.738***	1.353***
			(0.071)	(0.147)
Was last school attended a university? (Ref: no)	Yes			0.596***
				(0.097)
Program area (Ref: other)	Technology		0.569***	1.204
			(0.100)	(0.234)
	Business		0.589***	1.658***
			(0.093)	(0.292)
Credential (Ref: 2-year diploma)	Certificate 1 yr		0.162***	3.680***
			(0.038)	(1.012)
	Advanced Diploma 3 yr		1.266**	0.837
			(0.133)	(0.101)
English placement (Ref: college English – level 4)	ELL – Level 1 or 2	0.654***		0.845
		(0.099)		(0.157)
	Below College-Level/ELL – Level 3	0.909		1.307**
		(0.104)		(0.154)
Academic year of graduation (Ref: 2008-2011)	2012-2014			
Term of graduation (Ref: fall)	Summer	1.117	0.967	0.666**
		(0.146)	(0.137)	(0.109)
	Winter	1.722***	1.296**	0.708**
		(0.198)	(0.153)	(0.097)
Constant		1.176	1.532*	0.712
		(0.271)	(0.385)	(0.210)
Observations		2,671	2,058	1,636
R-squared		0.0438	0.0585	0.0817

Notes: Robust standard errors in parentheses; ***p<0.01, **p<0.05. Empty cells indicate dropped variables due to insignificance. A logistic model was run for all models (0/1 outcome). College math average excluded foundation math courses.

Employment Outcomes: by placement in foundation math

No association was found between placement in foundation math and the likelihood of finding a job (Table 22). However, graduates in the top 25th percentile for overall GPA were more likely to be employed than those in the lowest 25th percentile. In contrast with the results shown above for first-year academic performance and placement testing, being a Canadian citizenship and having English as a first language were positively associated with employment.

Contrary to the descriptive results, the regression models suggest that placement in foundation math did not affect a student's odds of employment in a field related to their program of study, or of being overqualified. However, those who graduated in the top half of the class in overall GPA were more likely to obtain a job related to their program than those in the lowest 25th percentile. Graduates with a GPA between the 25th and 49th percentiles were less likely to be overqualified. The effects of sociodemographic and program factors were similar to those described in the college math models.

Table 22. Regression analysis: The effect of placement in foundation college math on employment, job relatedness, and overqualification, Seneca graduates six months after graduation, 2007-2014

VARIABLES	LABELS	Employment	Related Job	Overqualified
Foundation math (Ref: No)	Yes	1.157	0.847	1.238
		(0.121)	(0.085)	(0.142)
Citizenship (Ref: non-Canadian citizen)	Canadian	1.477***	0.811**	1.736***
		(0.163)	(0.084)	(0.218)
First language was English (Ref: other)	Yes, English	1.375***		
		(0.146)		
Age at graduation (Ref: <22 years)	≥22 years	1.210	1.151	0.860
		(0.133)	(0.125)	(0.106)
Student gender (Ref: female)	Male	1.181	0.949	1.369***
		(0.106)	(0.091)	(0.149)
Parental education (Ref: parent has no degree/unknown)	Degree			
Did the student ever receive OSAP? (Ref: no)	Yes		0.748***	1.412***
			(0.066)	(0.141)
Seneca graduate GPA quartile (Ref: 0-24th percentile)	25th-49th Percentile	1.136	1.097	0.772**
		(0.126)	(0.123)	(0.098)
	50th-74th Percentile	1.282	1.609***	0.641***
		(0.163)	(0.206)	(0.093)
	75th-100th Percentile	1.677***	2.187***	0.454***
		(0.240)	(0.300)	(0.071)
Was last school attended a university? (Ref: no)	Yes			0.702**
				(0.109)
Graduated program group (Ref: other)	Technology		0.769	1.218
			(0.115)	(0.206)
	Business		0.716***	1.800***
			(0.091)	(0.261)
Graduated credential (Ref: 2-year diploma)	Certificate 1yr		0.174***	3.847***
			(0.036)	(0.928)
	Advanced Diploma 3 yr		1.246**	0.874
			(0.129)	(0.103)
English placement (Ref: college English – level 4)	ELL – Level 1 or 2	0.688***		0.726
		(0.098)		(0.130)
	Below College-Level/ELL – Level 3	0.891		1.171
		(0.093)		(0.127)
Academic year of graduation (Ref: 2008-2011)	2012-2014			
Term of graduation (Ref: fall)	Summer	1.181		
		(0.139)		
	Winter	1.589***		
		(0.167)		
Constant		1.296	1.812***	0.423***
		(0.246)	(0.341)	(0.095)
Observations		3,141	2,411	1,924
R-squared		0.0388	0.0644	0.0801

Notes: Robust standard errors in parentheses; ***p<0.01, **p<0.05. Empty cells indicate dropped variables due to insignificance. A logistic model was run all models (0/1 outcome).

Hourly wage: by first-year math average

The regression models provide evidence that grades in first-year college math are not associated with hourly wage, even when adjusting for either job-relatedness or overqualification (Table 23). However, higher hourly wages were associated with being a Canadian citizen, being male, having a parent with a degree and graduating with a more advanced credential; however, being placed in ELL 1/2 at college entry was associated with a lower hourly wage. None of the models showed that age at graduation, OSAP receipt, or previous university attendance was associated with hourly wage. However, obtaining a related job and not being overqualified were associated with higher wages.

Table 23. Regression analysis: The effect of first-year college math average on hourly wage among employed Seneca graduates, six months after graduation, 2007-2014

VARIABLES	LABELS	Hourly wage	Hourly wage incl. Related Job	Hourly wage Incl. Overqualified
College math average	4 pt. scale	0.013	0.002	0.003
		(0.007)	(0.007)	(0.007)
Related job (Ref: no)	Yes		0.185***	
			(0.016)	
Overqualified (Ref: no)	Yes			-0.203***
				(0.016)
Citizenship (Ref: non-Canadian citizen)	Canadian	0.062***	0.071***	0.079***
		(0.019)	(0.019)	(0.021)
First language was English (Ref: other)	Yes, English			0.037**
				(0.019)
Age at graduation (Ref: <22 years)	≥22 years	0.025	0.024	0.029
		(0.019)	(0.018)	(0.018)
Student gender (Ref: female)	Male	0.038**	0.043***	0.079***
		(0.017)	(0.016)	(0.017)
Parental education (Ref: parent has no degree/unknown)	Parent has a BA	0.041**	0.044***	0.042**
		(0.017)	(0.017)	(0.017)
Did the student ever receive OSAP? (Ref: no)	Yes			
Was last school attended a university? (Ref: no)	Yes			
Program area of graduation (Ref: other)	Technology	0.054**	0.076***	0.038
		(0.027)	(0.026)	(0.027)
	Business	-0.022	0.000	-0.024
		(0.024)	(0.023)	(0.024)
Credential of graduation (Ref: 2-year diploma)	Certificate 1yr	-0.143***	-0.071**	-0.067
		(0.032)	(0.034)	(0.035)
	Advanced Diploma 3 yr	0.077***	0.068***	0.085***
		(0.018)	(0.017)	(0.018)
English placement (Ref: college English – level 4)	ELL – Level 1 or 2	-0.082***	-0.073***	-0.061**
		(0.026)	(0.025)	(0.027)
	Below College-Level/ELL – Level 3	-0.013	-0.004	0.013
		(0.017)	(0.017)	(0.018)
Academic year of graduation (Ref: 2008-2011)	2012-2014		-0.032**	
Term of graduation (Ref: fall)	Summer			
	Winter			
Constant		2.533***	2.444***	2.590***
		(0.040)	(0.042)	(0.041)
Observations		1,760	1,760	1,447
R-squared		0.084	0.158	0.193

Notes: Robust standard errors in parentheses; ***p<0.01, **p<0.05. Empty cells indicate dropped variables due to insignificance. A linear model was run for all models (continuous outcome). Math GPA excludes foundation math grades. Hourly wage adjusted for 2014 real dollars using the Ontario CPI and natural log transformed.

Hourly wage: by placement in foundation math

The descriptive results show that graduates who took foundation math had lower hourly wages; the regression models, however, showed a different scenario (Table 24): Graduates who earned higher wages were older than 22 years of age and had obtained a more advanced college diploma, whereas those who earned lower wages had the lowest level of English-language proficiency at college entry. Interestingly, the wage model (which does not control for overqualification or job relatedness) showed that being male or having a parent with a degree had no significant effect, unlike the models that included college math or controlled for job relatedness or overqualification. College grades, OSAP receipt, or previous university attendance had no significant effect on hourly wage in any of the models.

Similar to what occurred in the models controlling for college math average, an increase in wage was observed for graduates who were employed in jobs related to their field of study and a decrease in wage was observed for graduates employed in jobs for which they were overqualified.

Table 24. Regression analysis: The effect of placement in foundation college math on current wage among employed Seneca graduates, 2007-2014

VARIABLES	LABELS	Hourly wage	Hourly wage incl. Related Job	Hourly wage Incl. Overqualified
Foundation college math (Ref: no)	Yes	-0.031	-0.026	-0.025
		(0.016)	(0.016)	(0.017)
Related job (Ref: no)	Yes	---	0.207***	---
			(0.015)	
Overqualified (Ref: no)		---	---	-0.233***
				(0.016)
Citizenship (Ref: non-Canadian citizen)	Canadian		0.065***	0.086***
			(0.018)	(0.018)
First language was English (Ref: other)	Yes, English			
Age at graduation (Ref: <22 years)	≥22 years	0.042**	0.032	0.037**
		(0.017)	(0.017)	(0.017)
Student gender (Ref: female)	Male	0.027	0.034**	0.071***
		(0.016)	(0.016)	(0.017)
Parental education (Ref: parent has no degree/unknown)	Degree		0.034**	0.036**
			(0.016)	(0.016)
Did the student ever receive OSAP? (Ref: no)	Yes			
Seneca graduate GPA quartile (Ref: 0-24th percentile)	25th-49th Percentile			
	50th-74th Percentile			
	75th-100th Percentile			
Was last school attended a university? (Ref: no)	Yes			
Graduated program group (Ref: other)	Technology	0.013	0.023	-0.018
		(0.026)	(0.025)	(0.026)
	Business	-0.080***	-0.056**	-0.084***
		(0.023)	(0.022)	(0.023)
Graduated credential (Ref: 2-year diploma)	Certificate 1yr	-0.184***	-0.099***	-0.086***
		(0.030)	(0.031)	(0.033)
	Advanced Diploma 3 yr	0.086***	0.068***	0.084***
		(0.018)	(0.017)	(0.017)
English placement (Ref: college English – level 4)	ELL – Level 1 or 2	-0.121***	-0.082***	-0.088***
		(0.023)	(0.024)	(0.025)
	Below College-Level/ELL – Level 3	-0.024	-0.002	0.008
		(0.016)	(0.016)	(0.017)
Academic year of graduation (Ref: 2008-2011)	2012-2014	-0.038**		
		(0.016)		
Term of graduation (Ref: fall)	Summer			
	Winter			
Constant		2.713***	2.484***	2.701***
		(0.023)	(0.028)	(0.026)
Observations		2,070	2,052	1,693

R-squared	0.078	0.160	0.200

Notes: Robust standard errors in parentheses; ***p<0.01, **p<0.05. Empty cells indicate dropped variables due to insignificance; --- indicates variables not included. A linear model was run for all models (continuous outcome). Hourly wage adjusted for 2014 real dollars using the Ontario CPI and natural log transformed.

Key Findings

Role of math proficiency on academic and labour market outcomes

This report shows that a strong math background in high school increases the likelihood that a student entering college will select a program requiring math and/or select a technology program. In turn, for students who enter college programs requiring math, math proficiency has a major effect on assessment test scores at entry, and academic and labour market outcomes.

For the population in the sample who had attended an Ontario high school, students who obtained a higher math average in high school and took advanced high school math courses were more likely to:

- select a college program requiring math and/or enter a technology program;
- have higher scores on college math placement tests (algebra, arithmetic, CAT-3) and lower odds of being placed in foundation math; and
- have higher first-year college math averages, higher overall college GPA and higher graduation rates.

For the full population in the sample, students with higher scores on college math placement tests had higher first-year math grades, higher overall college GPAs and higher graduation rates. Graduates with a higher first-year college math average were more likely to transfer to university, to be employed, to have a job related to their field of study, and to have lower odds of overqualification. However, for employed graduates, first-year college math average or placement in foundation math had no effect on their hourly wage.

In addition to math proficiency, sociodemographic and other factors interact in complex ways with math performance and academic and labour market outcomes. As described below, they include gender, aspirations for university, Canadian citizenship status, neighbourhood income and parental education.

Gender

Compared with female students, male students are more likely to take advanced math courses in high school, somewhat more likely to enter a program requiring math and much more likely to enter a technology field, even when controlling for high school background. Independent of high school background in math, male students also perform better than females on college math placement tests. Yet within programs requiring math, females obtain higher first-year college math averages, higher overall college GPAs, and are more likely to graduate. Labour market outcomes show that employed female graduates are less likely to be overqualified than their male counterparts, but they earn a lower hourly wage.

Aspirations for university

Interesting patterns were seen for students who entered college with plans to attend university, a group typically associated with choosing a program requiring math. However, students from this group who did so had poorer academic outcomes than students with no aspirations for university: they had lower first-year college math averages, lower overall college GPAs, and lower odds of graduation. Yet, those who ultimately graduated from college were far more likely to transfer to university than graduates who did not aspire to university at college entry.

Citizenship

For the most part, Seneca college students who are Canadian citizens are not performing as well as their non-Canadian counterparts. Canadian citizens were less likely to select a program requiring math, and those who did so had lower scores on college math placement tests, lower college math averages in first year, lower overall college GPAs, and lower odds of graduation. Of graduates who entered the labour force, citizens were more likely than non-citizens to be employed, but less likely in a job related to their college studies, and more likely to be overqualified. Despite these other outcomes, they were more likely to earn a higher hourly wage.

Neighbourhood income and parental education

Students from low income neighbourhoods and those who had a parent with a degree were more likely to enter a technology field. When controlling for parental education, students from high income neighbourhoods had higher scores on college math placement tests, higher math averages in first year, higher overall college GPAs, and higher graduation rates. Students who had a parent with a degree performed better on college math placement tests. Across all models investigating labour market outcomes, students who had a parent with a degree earned a higher hourly wage.

Time Trends

Although the study did not specifically focus on time trends, notable shifts in recent years were observed, even when controlling for differences in sociodemographic and select factors of entering students. The results showed a decline in college math placement scores, first-year college math averages, overall college GPAs and college graduation rates.

Summary

This study clearly shows the long-term repercussions of weak math proficiency: reduced likelihood of entering programs requiring math, lower first-year math and overall college grades, lower college graduation rates, and a reduced likelihood of obtaining a job related to program of study. Overall, results of the current study suggest that students who both obtain higher grades in math and take advanced high school math courses are more likely to select college programs that require math, and to perform better on required college math placement tests. In turn, higher math proficiency at college entry is positively associated with better overall college performance and a greater likelihood of graduation, transfer to university, and employment post-graduation. A variety of sociodemographic factors including gender, neighbourhood income, parental education, English-language proficiency and Canadian citizenship status interacted in complex ways that influenced program selection, math proficiency and graduate outcomes, and require further research.

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Appendices

Appendix 1. Conversion scales for Canadian Achievement test, version 3 (CAT-3)

# correct	Scale-equal interval	National Percentile end of grade 12 (Canadian population, year 2000)
0	366	<25%
1	368	
2	371	
3	381	
4	402	
5	423	
6	442	
7	458	
8	474	
9	490	
10	506	
11	519	
12	529	
13	541	
14	552	
15	563	25-<50%
16	573	
17	584	
18	595	
19	606	
20	618	
21	631	50%<75%
22	643	
23	656	
24	672	
25	688	75%-100%
26	707	
27	728	
28	752	
29	783	
30	815	

Appendix 2. Regression Model Building

For each multivariable regression model, purposeful selection, as proposed by Hosmer and Lemeshow (2000), was used to select potential confounding variables for inclusion in each analysis. For each independent variable, the unadjusted association with the dependent variable was estimated and those with a p-value ≤0.25 were selected for inclusion in the multivariable model. Variables of interest were assessed independently by removing each variable from the multivariable model one at a time. If the independent variables of interest or the corresponding standard errors changed by greater than or equal to 10% upon removal of a variable, the variable was included in the model. The likelihood-ratio (LR) test was used to assess whether inclusion of the variable significantly improved model fit. A variable was kept in the multivariable model if its inclusion statistically improved the fit of the model as determined by a LR test p-value of <0.05. Variables for students' gender and age were included in all regression models regardless of their statistical significance. Collinearity among independent variables of interest was inspected with cross-tabulation and the Pearson correlation coefficient. Variables that were highly correlated (with Pearson correlation coefficients ≥0.7) were further examined to determine which set of variables would be included in the final model (Vittinghoff, 2012).

Appendix 3. Mean arithmetic, algebra and CAT-3 scores by college GPA and graduate status of Seneca entrants, 2007–2014

		Arithmetic Scores /120 N=18,953		Algebra Scores /120 N=17,396		CAT-3 Scores N=10,567	
		Mean	95% CI	Mean	95% CI	Mean	95% CI
College GPA, up to first credential	<2.0	58.4	57.8, 59.0	55.7	55.1, 56.3	585.8	584.2, 587.5
	2.0-2.9	65.2	64.4, 66.0	64.2	63.3, 65.0	605.9	603.8, 608.1
	3.0-3.4	72.7	71.4, 73.9	71.5	70.1, 72.8	626.6	623.6, 629.6
	3.5+	81.4	80.1, 82.7	80.3	78.8, 81.8	647.5	644.2, 650.9
	Missing	60.3	55.8, 64.8	56.9	52.5, 61.4	599.1	586.9, 611.3
Graduated	No	61.3	60.7, 61.8	58.6	58.1, 59.2	598.0	596.5, 599.4
	Yes	69.5	68.8, 70.3	68.5	67.7, 69.3	613.8	611.7, 615.8

Note: CI= Confidence interval

Appendix 4. Overall GPA and graduation rates, by selected characteristics among Seneca entrants <23 years of age and not enrolled in a degree or graduate certificate program (2nd entry), 2007–2014. N=44,613

		College GPA N=44,188		Graduated On Time N=27,449		Graduated within an Extra Year N=27,197	
		Mean	95% CI	Prop. (%)	95% CI	Prop. (%)	95% CI
Age at entry (yr.)	<19	2.05	2.03, 2.07	34.6	33.7, 35.5	50.5	49.5, 51.5
	19	1.89	1.87, 1.91	29.5	28.5, 30.6	44.1	42.9, 45.3
	20-<23	2.08	2.06, 2.10	35.5	34.6, 36.4	47.6	46.6, 48.6
Gender	Female	2.22	2.21, 2.24	39.5	38.7, 40.3	53.8	52.9, 54.6
	Male	1.83	1.81, 1.84	28.0	27.2, 29.7	42.1	41.3, 43.0
	Missing	1.55	1.24, 1.87	18.5	9.3, 31.4	20.4	10.6, 33.5
Status in Canada	Citizen	1.99	1.98, 2.01	32.6	31.9, 33.2	46.4	45.7, 47.1
	Non-Canadian Citizen	2.14	2.11, 2.16	38.5	37.1, 39.8	54.4	53.1, 55.8
	Missing	1.78	1.67, 1.89	27.6	23.2, 32.3	39.8	34.9, 44.9
	Yes	2.04	2.02, 2.05	33.7	33.0, 34.4	46.9	46.2, 47.6

English as a first language	Other	1.99	1.97, 2.01	33.4	32.5, 34.3	49.4	48.4, 50.4
Parental education	Degree	2.11	2.09, 2.13	36.1	34.9, 37.2	49.8	48.6, 51.0
	No Degree/ Unknown	1.99	1.97, 2.00	32.8	32.1, 33.4	47.1	46.4, 47.8
Neighbourhood income	Low	1.93	1.91, 1.95	31.5	30.6, 32.4	45.3	44.2, 46.3
	Middle	2.03	2.02, 2.05	33.7	32.7, 34.6	47.9	46.9, 48.9
	High	2.08	2.05, 2.10	34.9	33.8, 36.0	49.5	48.3, 50.6
	Missing	2.28	2.23, 2.34	44.3	41.0, 47.7	59.6	56.3, 63.0
OSAP recipient	Yes	2.00	1.99, 2.02	31.9	31.1, 32.8	47.6	46.7, 48.5
	No	2.03	2.02, 2.05	34.9	34.2, 35.7	48.0	47.2, 48.8
High school courses mostly U or M	No	1.71	1.69, 1.73	25.5	24.6, 26.4	40.0	39.0, 41.0
	Yes	2.21	2.20, 2.23	38.9	38.1, 39.8	53.7	52.7, 54.6
	Missing	2.12	2.09, 2.14	36.3	35.1, 37.4	49.1	47.8, 50.3
HS average	<60%	1.04	1.00, 1.08	9.8	8.4, 11.4	20.8	18.8, 22.9
	60-69%	1.64	1.62, 1.66	23.8	23.0, 24.6	38.9	37.9, 39.8
	70-79%	2.40	2.38, 2.42	45.2	44.1, 46.3	60.3	59.2, 61.4
	≥80%	3.10	3.07, 3.14	63.1	60.5, 65.7	75.6	73.2, 77.9
	Missing	2.11	2.09, 2.14	36.2	35.0, 37.4	49.0	47.7, 50.2
How many 11/12 courses did a student fail?	0	2.33	2.32, 2.35	42.5	41.6, 43.5	57.9	56.9, 58.8
	1-3	1.73	1.71, 1.75	25.9	24.9, 26.9	40.4	39.3, 41.5
	≥3	1.32	1.28, 1.35	15.5	14.2, 16.9	27.4	25.8, 29.1
	Missing	2.12	2.09, 2.14	36.3	35.1, 37.4	49.1	47.8, 50.3
Eligible for university	No	1.82	1.81, 1.83	28.5	27.8, 29.2	43.6	42.8, 44.3
	Yes	2.67	2.64, 2.69	52.2	50.6, 53.7	64.7	63.2, 66.2
	Missing	2.12	2.09, 2.14	36.3	35.1, 37.4	49.1	47.8, 50.3
Last school attended was university	No	1.95	1.94, 1.96	31.6	31.1, 32.2	46.2	45.6, 46.8
	Yes	2.63	2.60, 2.66	52.9	51.0, 54.9	64.0	62.0, 65.9
College GPA, up to first credential	<2.0			4.6	4.2, 4.9	13.6	13.0, 14.2
	2.0-2.9			44.0	42.9, 45.1	70.5	69.5, 71.6
	3.0-3.4			74.0	72.6, 75.3	87.4	86.3, 88.4
	3.5+			82.1	80.7, 83.5	89.1	87.9, 90.2
	Missing			0.3	0.0, 1.9	0.3	0.0, 1.9
Graduated	No	1.57	1.55, 1.58				
	Yes	2.87	2.86, 2.88				

Note: CI= Confidence interval

Appendix 5. Proportion of students who took a college foundation math course or a first-year math course, and whose first program was technology, by selected characteristics among Seneca entrants <=23 years of age and not enrolled in a degree or graduate certificate program (2nd entry), 2007–2014

		Remedial College Math N=24,915		Took a First-Year College Math Course N=44,613		First Program was Technology N=44,613	
		Prop. (%)	95% CI	Prop. (%)	95% CI	Prop. (%)	95% CI
Age at entry (yr.)	<19	39.6	38.6, 40.6	51.9	51.1, 52.6	15.9	15.4, 16.5
	19	35.9	34.7, 37.1	57.0	56.0, 57.9	15.6	14.9, 16.3
	20-<23	29.8	28.9, 30.7	59.5	58.8, 60.3	14.9	14.3, 15.4
Gender	Female	34.9	34.0, 35.8	48.8	48.1, 49.5	6.0	5.7, 6.4
	Male	35.0	34.2, 35.8	62.6	61.9, 63.2	24.5	23.9, 25.1
	Missing	37.8	23.8, 53.5	62.5	50.3, 73.6	4.2	0.9, 11.7
Status in Canada	Citizen	40.2	39.5, 41.0	51.5	51.0, 52.0	14.9	14.5, 15.3
	Non-Canadian Citizen	20.3	19.3, 21.3	72.2	71.3, 73.1	18.0	17.2, 18.8

	Missing	34.1	29.1, 39.4	67.4	63.2, 71.5	11.5	8.9, 14.6
English as a first language	Yes	40.5	39.6, 41.3	50.0	49.4, 50.5	14.3	13.9, 14.8
	Other	28.0	27.2, 28.9	65.6	64.9, 66.3	17.3	16.8, 17.9
Parental education	Degree	28.8	27.7, 29.9	59.6	58.7, 60.5	18.5	17.8, 19.2
	No Degree/ Unknown	37.4	36.6, 38.1	54.5	54.0, 55.0	14.4	14.0, 14.8
Neighbourhood income	Low	35.8	34.8, 36.8	57.4	56.6, 58.2	16.1	15.6, 16.7
	Middle	35.1	34.0, 36.1	55.0	54.2, 55.8	14.9	14.3, 15.4
	High	36.0	34.8, 37.1	53.2	52.3, 54.1	14.7	14.1, 15.3
	Missing	22.7	20.4, 25.2	68.2	66.0, 70.4	20.0	18.1, 21.9
OSAP recipient	Yes	38.6	37.7, 39.5	54.7	54.1, 55.4	15.7	15.2, 16.2
	No	32.1	31.3, 32.9	56.7	56.1, 57.4	15.3	14.8, 15.8
High school courses mostly U or M (>50%)	No	54.9	53.8, 56.0	49.9	49.1, 50.7	14.4	13.9, 15.0
	Yes	27.8	26.9, 28.6	54.8	54.1, 55.5	16.6	16.1, 17.1
	Missing	23.5	22.5, 24.5	67.1	662.68.1	14.8	14.2, 15.6
High school average	<60%	54.2	51.5, 56.9	56.8	54.7, 58.8	11.4	10.1, 12.7
	60-69%	44.6	43.6, 45.7	54.9	54.1, 55.6	15.3	14.7, 15.8
	70-79%	31.8	30.7, 33.0	50.3	49.4, 51.1	16.9	16.3, 17.6
	≥80%	20.0	17.7, 22.4	45.4	43.4, 47.3	15.5	14.1, 17.0
	Missing	23.5	22.5, 24.5	67.1	66.2, 68.0	14.8	14.1, 15.5
How many 11/12 courses did a student fail?	0	36.5	35.5, 37.5	49.4	48.7, 50.1	16.2	15.7, 16.7
	1-3	42.2	41.0, 43.4	54.5	53.6, 55.4	15.2	14.5, 15.8
	>3	40.6	38.7, 42.5	60.4	58.9, 61.9	14.7	13.7, 15.8
	Missing	23.5	22.5, 24.5	67.1	66.2, 68.1	14.8	14.2, 15.6
Eligible for university	No	44.1	43.3, 44.9	53.0	52.4, 53.6	15.3	14.9, 15.8
	Yes	18.6	17.4, 20.0	50.8	49.7, 52.0	16.9	16.0, 17.8
	Missing	23.5	22.5, 24.5	67.1	66.2, 68.1	14.8	14.2, 15.6
Last school attended was university	No	37.3	36.7, 38.0	55.8	55.3, 56.3	15.1	14.7, 15.4
	Yes	14.3	13.0, 15.7	56.6	55.1, 58.0	18.9	17.8, 20.1
College GPA, up to first credential	<2.0	45.1	44.2, 45.9	61.4	60.7, 62.1	16.9	16.4, 17.4
	2.0-2.9	30.6	29.5, 31.7	55.6	54.7, 56.5	14.5	13.8, 15.1
	3.0-3.4	20.9	19.4, 22.4	47.1	45.9, 48.3	14.0	13.2, 14.9
	3.5+	12.9	11.6, 14.3	46.0	44.7, 47.4	13.7	12.8, 14.7
	Missing	36.9	30.4, 43.7	51.1	46.2, 55.9	18.4	14.8, 22.4
Graduated	No	38.5	37.8, 39.3	56.8	56.2, 57.4	16.4	16.0, 16.8
	Yes	27.8	26.9, 28.8	54.0	53.3, 54.8	13.7	13.1, 14.2

Note: CI= Confidence interval