Higher Education Quality Council of Ontario
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The Effectiveness of Tutorials in Large Classes: Do they matter?

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Published by

The Higher Education Quality Council of Ontario

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Cite this publication in the following format:

Menard, K., O' Shaughnessy, B., Payne, A. A., Kotlyachkov, O., & Minaker, B. (2015). *The Effectiveness of Tutorials in Large Classes: Do they matter?* Toronto: Higher Education Quality Council of Ontario.

The authors would like to thank the anonymous reviewers for their helpful comments.

Higher Education Quality Council of Ontario

Table of Contents

List of Tables

List of Figures

Executive Summary

This report examines the use and benefits of tutorials in a large enrolment first-year economics course. The primary objective of this study was to measure the relative merits of two different kinds of tutorials, a traditional tutorial, in which students listen to a teaching assistant work through a problem related to course material, and a collaborative tutorial, in which students work through a problem together in small teams with guidance from the teaching assistant. Assuming that at least part of the purpose of having tutorials in large classes is to increase student engagement, the study also examined student attendance in both types of tutorials as a proxy for engagement.

The intervention was conducted during the 2012/2013 academic school year in a large introductory macroeconomics class. This course was taught by a single instructor and had followed a similar structure for the last seven years. This course typically enrolls over 2,500 students each year across five sections, two in the fall semester and three in the winter. The students in this course represent all faculties across the campus, as the course is a pre-requisite for many programs. Thus the students taking this course are diverse in their backgrounds, particularly in their academic preparation. As is typical with economics courses, this course requires strong math and analytical skills.

With respect to attendance, the report finds that a high proportion of students participate in the first tutorial of the semester. Close to 70% of the students attended at least three tutorials but that less than half the students attended all five tutorials. Students who did not attend one of the first two tutorials were unlikely to attend any of the remaining tutorial sessions. First-year students, females and students applying for financial aid were more likely to attend tutorials. We find that students from high-income neighbourhoods are also more likely to attend tutorials.

Term test performance is, on average, improved by tutorial participation. Attending a single tutorial did not improve final exam or overall course performance, but attending more than one tutorial had a cumulative effect on exam and overall performance. A student who attended all five tutorials will likely have improved their course grade by two full points on a twelve-point grade scale.

With respect to tutorial type, we find that traditional tutorials have a stronger positive effect on course performance, as measured by student grades, than collaborative learning tutorials. This was contrary to our expectations. It may be that the tutorials were too large for the collaborative learning method to be effective. Each teaching assistant had almost 70 students per tutorial section, a size that may be better suited for the more traditional tutorial style. It may also be possible that having students in the traditional tutorial attempt the problem set ahead of the tutorial positively influenced performance in the course. There was, however, a stronger positive correlation between the collaborative learning tutorials and performance on optional online homework assignments.

Introduction

Across much of Ontario and Canada, a typical first-year university student experience involves enrolment in a large class. While there are many benefits for universities to using large classes from a financial and resource perspective, the impact on students, particularly those who are less strong academically, tends to be overlooked. Struggling students may not seek help and/or may disengage from their studies. Ultimately this disengagement may lead to poor decisions around the program of study, academic choices, such as individual course selection, made in later years and, in some instances, to dropping out.

In this report we examine the use of tutorials in a large-enrolment course and analyze the benefits of tutorials in such courses. The first goal of this study is to assess the impact on student performance of introducing biweekly tutorials to a large first-year class. In a traditional lecture class, students attend approximately three hours of lecture per week, with an instructor teaching from a podium at the front of a large lecture hall. Such classes usually enroll anywhere from 200 to 1,000 students. Tutorials allow smaller groups of students to meet outside of the lecture hall for additional instruction time. These tutorials are often led by upper-year undergraduate or graduate students and may include activities such as problem sets, group work, or discussion of current events as they relate to the course material.

We analyze an intervention conducted during the 2012/2013 academic school year for a large class in economics. This course typically enrolls over 2,500 students each year across five sections. The students in this course represent all faculties across the campus, as the course is a pre-requisite for many programs. The backgrounds of students and their level of preparation for the course vary. Previous attempts at low-cost interventions to improve student performance in this course were ineffective. For example, in 2009-2010, a random set of students who performed poorly on the first test were personally emailed by the instructor and provided with information on academic resources. Course performance, as measured by final grades, was no different for these students than for students who were not emailed but performed similarly on the first test.

The innovation in our study is to examine the effectiveness of collaborative learning in larger classes (approximately 500-600 students per class) and to compare and contrast the effectiveness of collaborative learning versus traditional tutorials: If tutorials in large enrolment courses are successful at engaging students, does it matter if the tutorial is conducted as a traditional tutorial (i.e., with a teaching assistant working through a problem with the students) or as a collaborative learning tutorial (i.e., groups of students working through a problem together and the teaching assistant providing assistance to the students)? In previous studies with smaller class sizes, most of the students participated in the tutorials. With very large classes, students may feel anonymous and attendance at tutorials may be lower than in a small class setting. As many departments face increasingly tight budgets, there is a trend towards eliminating tutorials, partly due to a perceived lack of student participation. Our study will begin to establish tutorial participation rates and identify which type of tutorial formats may be more beneficial in engaging students in large enrolment courses.

Overall, we find that a high proportion of students participate in the first tutorial. We also find that close to 70% of the students attend at least three tutorials but that less than half the students attend all five tutorials. We find a measurable impact of tutorial attendance on course exam grades and on the final grade. Students who participated in all five tutorials performed better than those who only attended three tutorials. The traditional tutorials have a stronger (positive) effect on course performance than collaborative learning tutorials. There is, however, a stronger positive correlation between the collaborative learning tutorials and performance on optional online homework assignments.

Collaborative learning has been studied extensively in science and engineering programs. Collaborative learning, or cooperative learning, has many definitions, but usually involves students learning as much from each other as from their instructor or teaching assistant. In our study, collaborative learning tutorials meant that students worked through problem sets in small groups instead of having a teaching assistant present the solutions to the class as a whole. Felder (1995) and Felder, Felder and Dietz (1998) found that collaborative learning and active learning improved student outcomes and student satisfaction in a sequence of large (90 to 123 students) chemical engineering courses. The instructional techniques used in the Felder studies, however, did not seem to help the weakest students in the class. A meta-analysis of 39 studies in science, mathematics, engineering and technology courses showed a positive and statistically significant impact on student achievement, motivation and attitudes when cooperative learning or collaborative learning methods were used (see Springer, Stanne & Donovan, 1999).

Two studies have examined collaborative learning in the social sciences but for relatively smaller classes than what is being studied here. Yamarik (2007) studied class sizes of 25 to 35 students and focused on students in their second or third year of university. He found collaborative learning classes to be more effective in encouraging student success than traditional classes. Huynh, Jacho-Chaves and Self (2010a; 2010b) studied classes of 200 students in their first year of study. They found benefits to collaborative learning but lacked an experimental design that allowed them to compare the benefits to other methods such as traditional tutorials. A key finding of Huynh, Jacho-Chaves and Self (2011) is that collaborative learning had a particularly strong positive impact on students falling in the bottom 40^{th} percentile of the final course grade.

Experiment Design

Our experiment focused on the instruction of introductory macroeconomics at an Ontario university. This course was taught by a single instructor and had followed a similar structure for the last seven years. Each year, five sections of the course were offered: two in the fall (September to December) and three in the winter (January to April). The enrolment in each section ranged between 400 and 600 students, with a total enrolment of approximately 2,400 students each academic year. At the university under study, students taking introductory macroeconomics come from a variety of faculties, as there are several programs across the various faculties for which this course is required (e.g., engineering, commerce). Thus the students taking this course are diverse in their backgrounds, particularly in their academic preparation. As is typical with economics courses, this course requires strong math and analytical skills.

Prior to the year in which tutorials were introduced, students were evaluated based on their performance on two term tests and a final exam. The instructor offered optional online homework assignments. A student who completed the online homework assignments could use her performance to reduce the weight allocated to her final exam. For a student who chose not to complete the online homework assignments, the final grade was allocated as follows:

- 25% of the marks received on the better of two term tests (typically test 1)
- 20% of the marks received on the other term test
- 55% of the marks received on the final exam

If a student completed the online homework assignment, the weight of the final exam was reduced to 40%. The 15% for the online homework was allocated as 5% of the marks received on a basic math test offered in the first two weeks of the course and 10% of the marks received on weekly homework assignments. The math component of the online homework was designed to review concepts learned in high school.

Tutorials were provided for the students in introductory macroeconomics for the first time in two decades during the 2012/2013 academic year. Unless a teaching assistant was ill for a particular class, each tutorial section was led by the same teaching assistant. Tutorials were held biweekly. There were five tutorials held each semester, beginning in Week 4 in the fall and Week 2 in the winter. The scheduling differences were due to different starting days each term (classes began on a Thursday during the fall term and on a Monday during the winter term), differing schedules for when students could add and drop courses, and rigid term test dates. In the fall, most tutorials had an enrolment of approximately 70 students, with two exceptions. The tutorials that met from 8:00 pm to 8:50 pm on Tuesdays and Wednesdays had 15 and 19 students, respectively.

Table 1 shows which textbook chapters were covered in each of the five tutorials, along with test and exam coverage for both terms. While the specific chapters covered differ slightly across terms, test 1 covered material addressed in tutorials 1 and 2, test 2 covered material addressed in tutorials 3 and 4, and the final exam included material from tutorials 2 through 5.

Table 1: Material Covered in Tutorials and Test/Exams

Tutorial Number	Tutorial Content Term 1 (Traditional Tutorials)	Tutorial Content Term 2 (Collaborative Learning Tutorials)	Test/Exam Coverage
1	Chapters 1-3	Chapters 1-3	
2	Chapters 4-6	Chapters 4-6	Test 1 – Chapters 1-6
3	Chapters 7-9	Chapters 7-8	
4	Chapters 10-11	Chapters 9-11	Test 2 – Chapters 7-11
5	Chapters 12-13	Chapters 12-13	Final Exam – Chapters 5-15

Tutorials were fundamentally different in the fall and winter semesters. In the fall, teaching assistants (TAs) stood in front of the tutorial section and delivered a "traditional" tutorial by solving a set of problems on a blackboard. Students were expected to bring questions and problems to the tutorial, having printed them from the course learning management system the week before and attempted them on their own. The TA showed the solutions, provided a corresponding multiple choice question and went through the answer to that as well.

Tutorials in the winter semester aimed to create a collaborative learning environment. Students were given the problem sheets at the beginning of the tutorial and told to work on the questions in small groups. Again, each chapter had two or three short-answer problems with accompanying multiple-choice questions. Students worked in groups of three or four for approximately 30 minutes and then shared their answers with other groups working nearby. TAs traveled throughout the room and assisted groups as needed. They were instructed to provide guidance but not to tell the students the answers to the problems. Answers to most questions were provided the following week, either during lecture or via the course website.

To ensure tutorial attendance, the instructor offered an incentive. The tutorials did not count for grades but students were offered a "grade weight shift." This allowed students to shift a small portion of the weight from the final exam to their higher term test grade. Students who performed better on the final exam than on both tests would not be penalized because their shift would work in the opposite direction. Historically, the course average was higher on test 1 than on test 2, and both term test averages were typically higher than the average on the final exam. Typically only 5% of the class performed better on the final exam than on both term tests. The percentage shift is described in Table 2.

Table 2: Grade Weight Shift for Tutorial Attendance

Attend all five tutorials	Shift 5% of final exam weight to highest term test grade. This results in the better term test being worth 30%.
Attend four tutorials	Shift 4% of final exam weight to highest term test grade. This results in the better term test being worth 29%.
Attend three tutorials	Shift 3% of final exam weight to highest term test grade. This results in the better term test being worth 28%.
Attend zero to two tutorials	No weight shift, grade is calculated according to scheme described above.

Data Description, Sample Selection and Summary Statistics

To study the effects of offering tutorials in large classes, four data sources were utilized. The primary data were the records of the students in the course. The measures from this source captured information on (a) student tutorial participation, (b) performance on two course exams and one final exam, (c) participation in and performance on the online homework assignments, (d) adjusted final course grade (excludes performance on the online homework assignments), (e) an anonymous identification of the tutor assigned to each section. These measures were collected for students who participated in the course for both the 2011-2012 academic year (pre-tutorials, control) and the 2012-2013 academic year (tutorials, treatment).

The second data source was obtained from registrar data held at the university. The core measures collected from the registrar were program of registration and enrolment, and performance in all courses by the student. The third data source was information on the applications submitted by the students for admission to the university. The data on applications included applications for students applying directly from an Ontario high school (known as “101” students) and delayed entry and/or non-Ontario high school students (known as “105” students). The 101 set of applications captured information on the students’ performance in level 4 (grade 12) courses in high school and their home postal code. For the 105 set of applicants the high school grade information was more limited. The location of their residence and home postal code (if from Canada), however, were available. Using the home postal code measures from the fourth data set, the socio-economic characteristics of the neighbourhood where the student’s family resided were added based on the 2006 Canadian census. The census geography utilized was the dissemination area, a geography that covers roughly 500 households.

The core sample studied in this report includes those students enrolled in the course and for whom we observe information from their university application and who received a final grade in the course. We therefore include in our sample a total of 4,384 students out of the 4,777 who were initially enrolled in the course. Some of these students, however, are observed repeating the course, leaving us with a total of 4,342 unique students. The enrolment in the fall term is lower than the winter term given that one fewer section of the course was offered.

Informed consent was obtained from participants using an “opt-out” consent method. Data were collected on all students enrolled in the course during the year of study. At the end of the year, students received a letter of consent via email, which was also posted on the department website. Students who did not wish to participate in the research study clicked on an email link and their data were dropped from the sample. Both this process and the study protocol were approved by the university’s research ethics board.

In this study, all students in a given term either had no access to tutorials, or they attended the same format of tutorial (traditional lecture or collaborative learning). Because we do not have a random experimental design, it is important to examine our sample of students. In Table 3 we compare the students in our sample with students in the rest of the university under study and with university students across Ontario. This information is important since we would like to know whether or not our results are generalizable to other courses within this particular university and to other universities across the province. Table 4 provides a comparison of students in each of the control terms (no tutorials) with students in traditional tutorials and collaborative learning (CL) tutorials. Again, if our sample students are sufficiently alike, we have confidence that any findings will be due to the use of tutorials and not due to differences in the underlying samples.

Table 3: Comparison of the Study Sample and the General Student Population

	Sample students	All(1) students at university under study	All(2) Ontario students
	(1)	(2)	(3)
Total students in sample	**4,342**	**9,541**	**130,282**
Delayed or non-Ontario students (% 105 students)	11.8%		
Gender (% male)	**64.7%**	**47.0%**	**44.1%**
Immigrant status			
Canadian citizen	78.3%	88.5%	90.9%
Permanent resident	9.1%	7.0%	5.7%
Other	12.6%	4.6%	3.4%
Years in Canadian K-12 school system			
6 years or more	77.5%	88.6%	90.8%
3-5 years	12.7%	6.7%	4.8%
2 years or less	9.8%	4.7%	4.4%
% with English reported as their primary language	**65.9%**	**75.5%**	**76.9%**
Indication on application that an application for financial aid was submitted (% applied)	60.9%	67.9%	65.8%
Students with ON postal code (3)	**4,024**	**9,510**	**129,925**
% living in low-income neighbourhood	13.2%	14.5%	20.3%
High school GPA (best 6 university or mixed courses)			
Average best 6 GPA	86.5%	86.6%	83.7%
(standard deviation)	(5.0)	(5.5)	(6.5)
(Note: Differences of group means between columns 1 and 2 are not statistically different from zero. The differences in means between the university under study and all Ontario students, however, is statistically different at the 1% confidence level)			
5th percentile of best 6	78.3%	77.2%	72.7%
Median best 6	86.2%	86.7%	83.8%

	Sample students	All[1] students at university under study	All[2] Ontario students
	(1)	(2)	(3)
95th percentile of best 6	95.5%	95.7%	94.2%
Students by program of registration, Year 1 [4]			
Commerce (includes social sciences)	28.8%	11.8%	14.1%
Engineering	28.2%	20.3%	9.3%
Science/Health	22.6%	32.7%	28.9%
Humanities	15.5%	30.2%	39.0%
Other	5.0%	5.1%	8.7%

NOTES:

(1) All students who applied directly from high school in 2011 and 2012 and were registered at the university under study. There are a few students who are observed taking the course in more than one term.

(2) All students who applied directly from high school in 2011 and 2012 and were registered at any university.

(3) OUAC 101 students (direct applicants) may have a non-Ontario postal code if they attend an international Ontario-approved high school. For schools located in Ontario, school postal code was used if student postal code was invalid.

(4) Program of registration is based on transcript data for column 1 and application data for columns 2 and 3

In Table 3 the characteristics of the students under study were compared with the characteristics of the 101 students who first enrolled in the university under study in 2011 or 2012 (column 2) and all Ontario direct-entry students observed registering at an Ontario university in 2011 or 2012. As a portion of the students in the course are beyond their first year of study (second year mostly), we compare the entering characteristics of these students based on the information provided in their application. As shown in Table 3, there are proportionally more males in the course than at the university and in the entire system. There are fewer students in the course who are Canadian citizens, spent six or more years in the Ontario K-12 system, and who report English as their primary language in the course than at the university or in the province. A lower proportion of the students indicated that they applied for financial aid on their university application form and, of those with an Ontario postal code, there was a lower proportion of students whose family address is located in a low-income neighbourhood (bottom tercile of neighbourhoods). There are small but not statistically significant differences in entering high school averages, with the students under study reporting slightly lower entering averages relative to all students at the university under study but with these students reporting higher averages than that reported for all registrants. Finally, the students in the study more heavily represented commerce and engineering than science and humanities. Thus, overall the students under study were more likely to be foreign-born, male, from higher income families, and more interested in commerce and engineering.

Table 4: Demographic Characteristics of Sample Students: Comparison Across Terms

	Traditional Tutorial		Collaborative Learning	
	Control (2011)	Treatment (2012)	Control (2012)	Treatment (2013)
	(1)	(3)	(2)	(4)
Total students per term	**704**	**861**	**1,454**	**1,365**
Gender (% male)	62.2%	63.8%	66.2%	65.1%
Immigrant status				
Canadian citizen	77.4%	78.8%	76.8%	79.3%
Permanent resident	7.7%	9.2%	10.8%	8.1%
Other	14.9%	12.1%	12.4%	12.6%
Students by number of years in Canadian school system (at admission)				
6 years or more	76.3%	77.6%	76.1%	78.8%
3-5 years	15.2%	12.7%	12.9%	11.7%
<= 2 years	8.5%	9.8%	11.0%	9.6%
% with English reported as their primary language	64.6%	65.4%	65.3%	67.1%
Students by OSAP application status				
Applied for OSAP (% applied)	56.0%	63.9%	61.6%	60.2%
Students by neighbourhood of residence (if residing in Ontario at admission)				
Students with ON postal code	643	800	1,356	1,259
% living in low income neighbourhood (bottom tercile)	12.3%	14.8%	14.6%	14.9%
% living in mid-income neighbourhood (middle tercile)	32.8%	33.4%	31.1%	31.2%
% living in high income neighbourhood (top tercile)	54.9%	51.9%	54.4%	53.9%
Median distance to the university, km	47.6	47.0	46.9	48.7
High school GPA (best 6 university or mixed courses)				
Average best 6	**85.6**	**86.3**	**86.4**	**87.2**
Standard deviation of best 6	(4.6)	(4.7)	(4.9)	(5.3)
Grade difference with Fall 2011 students		**0.7**		
		(0.3)***		
Grade difference with Winter 2012 students				**0.8**

	Traditional Tutorial		Collaborative Learning	
	Control (2011)	Treatment (2012)	Control (2012)	Treatment (2013)
	(1)	(3)	(2)	(4)
				(0.2)***
Median best 6	85.3	85.9	85.8	86.7
High school math (average of all grade 12 university-stream courses)				
# students with at least one math course	**598**	**729**	**1263**	**1166**
(% 101 students)	97.1%	96.2%	97.8%	97.4%
(% of all students)	84.9%	84.7%	86.9%	85.4%
# level 12 math courses taken				
0	18	29	29	31
1	44	56	67	64
2	372	432	794	749
3 or 4	182	241	402	353
(no high school course information)	88	103	162	168
Average of best math grade	**86.1**	**86.9**	**87.6**	**88.0**
(standard deviation)	(8.7)	(8.6)	(7.9)	(8.4)
Median best math grade	87	89	89	90
Performance in course online math test	81.9	79.4	82.0	80.0
(standard deviation)	(30.4)	(33.0)	(31.3)	(33.2)
Students by enrolled faculty at time of course				
Business	38.6%	26.7%	28.3%	24.3%
Social sciences	14.2%	15.0%	11.8%	15.3%
Engineering	23.2%	24.9%	31.6%	28.6%
Science/Health	19.7%	28.7%	25.0%	27.7%
Humanities	3.8%	3.7%	2.9%	3.7%
Not declared or not applicable	0.4%	1.0%	0.4%	0.5%
Share students registered in level 1	73.2%	68.6%	79.78%	76.12%
Concurrent or past enrolment in first-year microeconomics course				
Number of students	228	327	1,305	1,159
Mean performance in microeconomics course (scale of 12)	7.9	8.0	7.5	8.4

	Traditional Tutorial		Collaborative Learning	
	Control (2011)	Treatment (2012)	Control (2012)	Treatment (2013)
	(1)	(3)	(2)	(4)
(standard deviation)	(3.1)	(3.1)	(3.0)	(3.1)
Overall term performance				
What was the total # credits taken in the term				
Average # of credits	**13.2**	**13.6**	**13.9**	**13.8**
(standard deviation)	(3.4)	(3.3)	(3.5)	(3.6)
Minimum credits	3	3	3	3
Median credits	12	15	15	15
Max credits	21	21	21	21
Share of students with "full-time loads"	79.1%	82.6%	83.2%	81.1%

Do our students vary across terms? Table 4 shows the characteristics of the students in our study grouped by term of enrolment in the course. There are marginal differences across the terms in most of the measures. The core differences are the proportion of students who are male (more in the winter terms) and the proportion residing in low-income neighbourhoods (smaller proportion in fall 2012). In terms of preparation, the students in the winter term had slightly higher high school GPAs and higher averages for their best level 4 math course in high school. Presumably these differences are driven by the fact that a greater share of students are enrolled in the engineering faculty in the winter term, typically for scheduling reasons, and engineering students typically enter the university with better grades due to high admission standards and are also more math-oriented, an important factor in the course under study.

Analysis

Tutorial Attendance

The first set of analyses focuses on participation in tutorials. Tutorials were offered to all students enrolled in the course during the 2012/2013 academic year. Offering tutorials and participating in tutorials, however, are not identical. Given that a core justification for introducing tutorials was to engage students, especially those likely to face difficulties in the first year of university studies, a first analysis focuses on participation in the tutorials and developing a better understanding of who participates and to what extent.

Figure 1: Tutorial Attendance

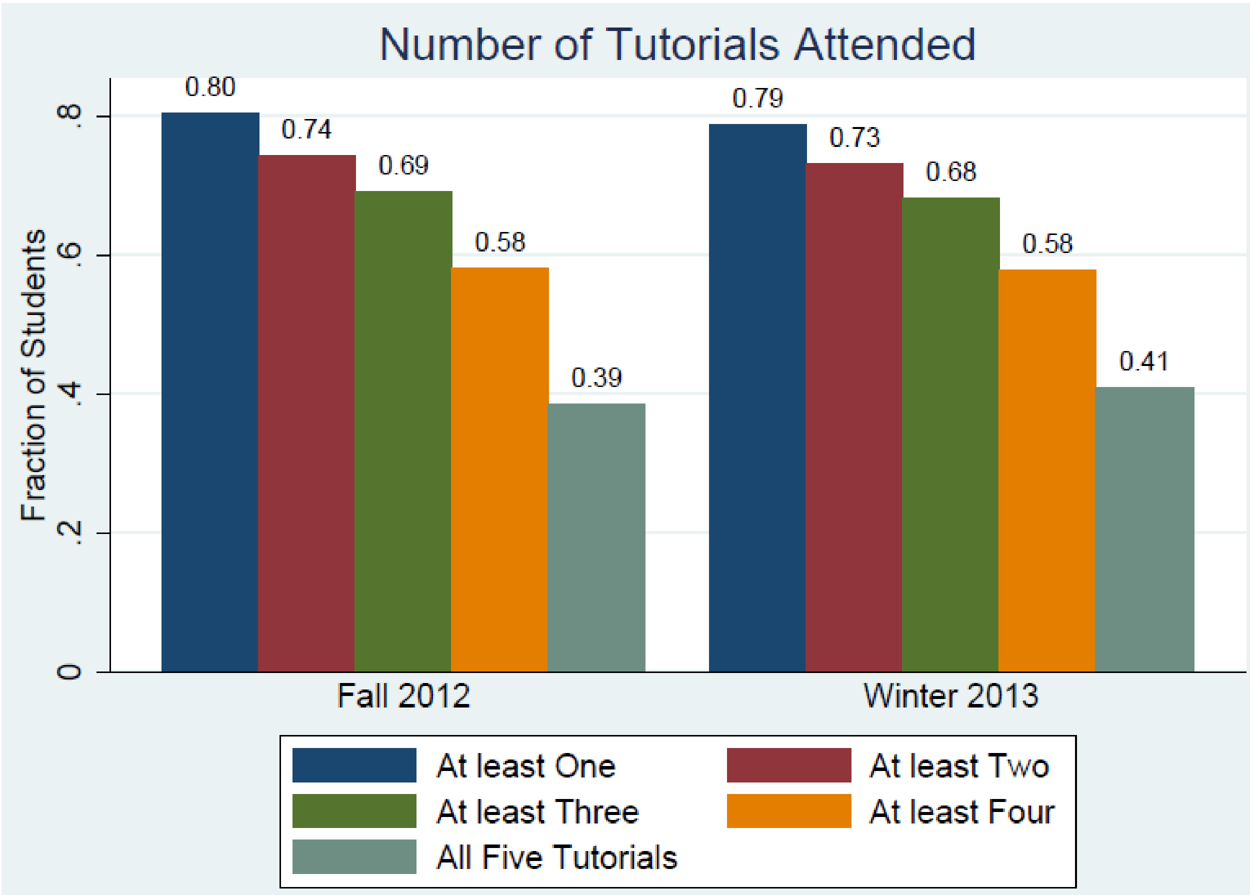
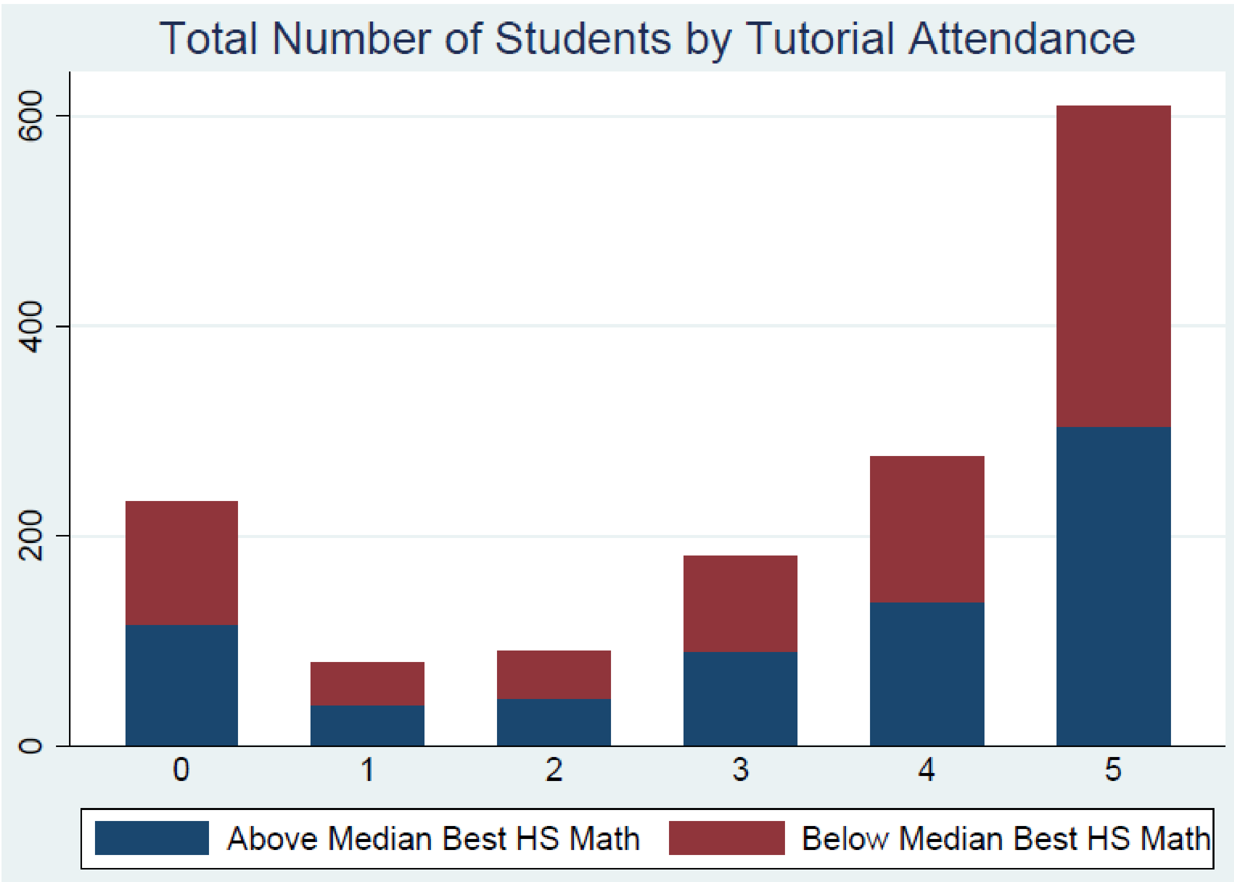


Figure 1 depicts students' tutorial attendance in both course sections. In both terms, a large share of students attended at least one tutorial, with most students (~70%) attending at least three tutorials. Less than half the students attended all five tutorials. A key component to tutorial attendance was participation in the first and/or second tutorial. If a student failed to attend the first or second tutorial, the student was not observed attending the remaining tutorials. In the fall term, there were 168 students who did not attend at least one of the first two tutorials. Less than 10% of these students (14) were observed attending a future tutorial. Similarly, in the winter term, there were 299 students who failed to attend at least one of the first two tutorials. Less than 4% of these students (9) were observed attending a subsequent tutorial.

To what extent is tutorial attendance correlated with being more academically prepared? While there is no perfect measure of academic preparation, we can look at the relationship between performance in high school, as measured by the best level 4 (grade 12) math grade, and tutorial attendance. As mentioned in the introduction, strong math skills are required for successful completion of the course under study. In Figure 2 we show the number of students who attend zero to five tutorials based on whether their best level 4 math grade is above or below the median math grade for the students in the course. Across the board, it appears that approximately half of the students fall above and half of the students fall below the median. So there is no prima facie evidence that only the better academically prepared (as measured by math grades) students are attending the tutorials.

Figure 2: Tutorial Attendance and Grade 12 Math Performance



Are there other observed characteristics that are correlated with tutorial attendance? Regression results (not reported) indicate that students with higher high school math marks are less likely to attend. The following types of students are more likely to attend tutorials: females, first year, full time, and those who applied for financial aid. There was some difference in likelihood of attending tutorials based on faculty of enrolment, but these were not uniform across the two terms. Neighbourhood characteristics were unrelated to a students' likelihood of attending tutorials. Overall, while there are some differences based on observed characteristics in the likelihood of attending a tutorial, the evidence does not overwhelmingly support the notion that less prepared students do not attend the tutorials.

Test Performance

Does offering tutorials matter for student performance? We turn next to observed performance on the two term tests. In Table 5 we report the average performance on the two term tests across the four terms. As we demonstrated above, there are differences in the composition of the student sample across terms. We therefore compare the students in tutorials based on tutorial type (traditional vs. collaborative) and enrolment term. Beginning first with the traditional tutorials (columns 1 and 2), average performance on term test 1 is similar across the two years. Average student performance on term test 2 is higher in the term with tutorials but average student performance on the final exam is lower. Stronger performance on test 2 is contrary to what has been observed historically in this course (that performance is lower on test 2), raising some suggestion that the tutorials may have had an effect on the understanding of the concepts and thus on test 2 performance. The decline in performance on the final exam is somewhat puzzling. Recall, however, that the weight attributed to a student's final exam is shifted to performance on the best test if the student attended tutorials. Thus, this decline in performance on the final exam might reflect a strategic decision by students seeking to achieve some predetermined minimum grade rather than maximizing their knowledge of the subject matter. Without more information, however, we cannot explore such a hypothesis.

Turning next to the collaborative learning tutorials, average performance on the term tests and final exams is lower in the term with the tutorials. This is perplexing. Recall, however, that there were lower shares of students enrolled in engineering and business programs in winter 2013 than in winter 2012. Also, there was a lower share of students who took two or more grade 12 math courses in the 2013 versus 2012 term. Collaborative learning tutorials were offered during the winter term, so the sample differences across years may be playing a role.

Table 5: Average Student Performance on Term Tests and Final Exam

	Traditional Tutorial			**Collaborative Learning Tutorial**		
	Control (2011)	**Treatment (2012)**	**Fall vs. Fall Treatment – Control**	**Control (2012)**	**Treatment (2013)**	**Winter vs. Winter Treatment – Control**
Total students in sample	704	861		1454	1365	
# of students repeating the course				10	8	
Average test 1 (0-100)	71.8	71.7	-0.1	76.4	72.8	-3.6
(standard deviation)	(14.1)	(15.2)		(13.6)	(18.1)	
Average test 2 (0-100)	63.9	68.0	4.1	72.4	65.4	-7.0
(standard deviation)	(16.5)	(20.8)		(16.5)	(19.5)	
Average final exam (0-100)	68.7	62.8	-5.9	65.0	61.4	-3.6
(standard deviation)	(15.8)	(14.2)		(15.0)	(14.8)	

In Table 6, we report the regression results using performance on the terms tests as the dependent variable. In columns 1 and 2, performance on term test 1 is the dependent variable. Tutorials 1 and 2 included material covered on this test, so we explore the effects of attendance in either or both of these tutorials on test performance, after controlling for background characteristics of the students and the neighbourhoods in which their parents reside. The results in column 1 reflect overall tutorial participation during the 2012-2013 school year. The results in column 2 allow for a differential effect of the collaborative learning tutorial and also explore whether there is a differential effect for students who are observed with high school marks falling below the median of the students enrolled in the course.

Overall, there was a positive effect of tutorial participation on test performance. Participation in one or both tutorials increased performance on the test an average of 2 to 2.5 percentage points. There was, however, no discernable difference of the collaborative learning form of tutorial on performance. The coefficient on the interaction term for the tutorial participation and having a below median math mark is negative but imprecisely measured.

We examine the impact of tutorials on term test 2 in columns 3 and 4. For this test, the material covered in tutorials 3 and 4 were most relevant. Given that we observe a difference in participation in these two tutorials, we include separate measures for participating in the two tutorials. Overall, participating in tutorial 3 increased performance on the test by 2.4 percentage points overall and over 4 percentage points for the traditional tutorials. Participating in both tutorials increased performance an average of between 4.3 and 8.7 percentage points. Although not always precisely measured, there is some evidence that the collaborative learning tutorials did not increase performance to the same degree that the traditional tutorials did.

Table 6: Effects of Tutorials on Term Tests

Dependent Variable	**Test 1**		**Test 2**	
	(1)	**(2)**	**(3)**	**(4)**
Attended Tutorial #1 and/or Tutorial #2	1.99***	2.50***		
	(0.53)	(0.54)		
* Collaborative Learning		-0.17		
		(-0.37)		
* Below Median High School Average (Best 6 Grade 12)		-1.20		
		(-0.51)		
Attended Tutorial #3			2.42*	4.39**
			(1.08)	(1.49)
* Collaborative Learning				-4.52**
				(-1.88)
* Below Median High School Average (Best 6 Grade 12)				1.26
				(1.979)
Attended Tutorial #4			3.51***	4.34***
			(1.08)	(1.48)
* Collaborative Learning				-2.10**
				(-1.89)

Dependent Variable	Test 1		Test 2	
	(1)	(2)	(3)	(4)
* Below Median High School Average (Best 6 Grade 12)				0.94
				(2.02)
Observations	4,359	4,359	4,359	4,359
R-squared	0.21	0.21	0.13	0.14

Robust standard errors clustered by neighbourhood reported in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Other control measures included were: best high school average, below median high school average, gender, first year, faculty of enrollment, previously or concurrently taking companion economics course, and neighbourhood characteristics.

Final Exam and Overall Course Performance

Do the tutorials affect the final exam and performance in the course? In Table 7 we report the results using the final exam marks and the overall course grade as dependent variables. For all specifications, we include indicator variables for participating in at least one tutorial, the total number of tutorials attended and the interaction terms between the number of tutorials attended, the collaborative tutorial and being below the median on high school marks. In column 1 we use as a dependent variable the final exam marks. In columns 2 and 3 we use as a dependent variable the overall grade in the course. In column 2 the overall grade includes marks attributed for undertaking the online homework and participating in tutorials. In column 3, the overall grade excludes marks assigned for these two items, thus only accounting for performance on the two term tests and the final exam.

Overall, attending a single tutorial has either no or a relatively small negative effect on final exam and overall course performance. There is an increasingly positive effect of attending several tutorials on these measures of performance. The effect of the collaborative learning tutorials, however, is slightly smaller than the traditional tutorials. For example, a student who attended all five traditional tutorials improved her final exam mark by 5.9 percentage points and her overall grade (adjusted) by 6.8 percentage points. If the same student attended all five collaborative tutorials, her final exam mark improved by 5.2 percentage points and her overall grade increased by 6.2 percentage points. There is no discernable effect of the tutorials on the performance of students who entered the course at the lower end of the distribution based on high school marks.

Any grade difference of more than 3 percentage points is meaningful to the students in the sample. The university under study uses a twelve-point grading system to calculate cumulative averages, where an “F” equals zero, “D-” equals one, “D” equals two, up to “A+” equaling twelve. For grades in the “D”, “C” and “B” ranges, an increase in grade of three percentage points is enough to move a student up to the next grade level. For example, a student with a grade of 67% has a C+, which translates to six out of twelve, while a student with 70% has a B-, which is seven out of twelve.

Table 7: Effects of Tutorials on Final Exam and Overall Grade Performance

Dependent Variable	**Final Exam**	**Overall Grade: Unadjusted**	**Overall Grade: Adjusted**
	(1)	(2)	(3)
Ever Attend A Tutorial	-1.64	-0.68	-1.59
	(-1.13)	(-0.99)	(-1.11)
Number of Tutorials Attended	1.47***	1.61***	1.62***
	(0.26)	(0.22)	(0.25)
* Collaborative Learning	-0.75***	-0.48***	-0.65***
	(-0.16)	(-0.13)	(-0.13)
* Below Median High School Average (Best 6 of Grade 12)	-0.27	-0.03	-0.12
	(0.17)	(0.14)	(0.15)
Observations	4,359	4,359	4,359
R-squared	0.34	0.39	0.38

Robust standard errors clustered by neighbourhood reported in parentheses
*** p<0.01, ** p<0.05, * p<0.1
Other control measures included were: best high school average, below median high school average, gender, first year, faculty of enrollment, previously or concurrently taking companion economics course, and neighbourhood characteristics

Discussion

Participation rates in the optional tutorials were quite high, with almost 70% of students attending at least three out of the five tutorials offered. Students who did not attend one of the first two tutorials were unlikely to attend any of the remaining tutorial sessions. First-year students, females and students applying for financial aid were more likely to attend tutorials. To the extent that these are high-risk groups for withdrawing from a course or from the university, these findings support the practice of offering tutorials. Countering that, we find that students from high-income neighbourhoods are also more likely to attend tutorials.

Term test performance is, on average, improved by tutorial participation. Attending a single tutorial did not improve final exam or overall course performance, but attending more than one tutorial had a cumulative effect on exam and overall performance. A student who attended all five tutorials will likely have improved their course grade by two full points on a twelve-point grade scale.

Traditional tutorials appear to help students more than collaborative learning tutorials, which was not expected. It may be that the tutorials were too large for the collaborative learning method to be effective. Each teaching assistant had almost 70 students per tutorial section, a size that may be better suited for the more traditional tutorial style. It may also be possible that having students in the traditional tutorial attempt the problem set ahead of the tutorial positively influenced performance in the course. With tight budgets and large section sizes, the traditional tutorial may be an effective means of using limited resources toward student academic success.

We are also disappointed that students at the lower end of the distribution were not helped more by adding tutorials to the course. The research so far is mixed on this issue, with some studies finding that tutorials have a greater impact on weaker student performance, while others do not (Felder, Huynh, Jacko-Chaves & Self, 2010b). Overall, we found that student participation in tutorials helped performance in the course and believe that these gains in learning are worth the cost of offering tutorials.

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