MAT133Y5Y - Calculus and Linear Algebra for Commerce

Fall 2018 - Winter 2019 Report

April 18, 2019

## Contents



# 1 Introduction

This report is to keep you apprised of the progress of MAT133 this year, including changes to content, delivery, grade reports, attrition statistics, and planned changes for future years. Having met with representatives from both Economics and Management in the Spring/Summer of 2018, some topics covered in the 2017-2018 year were dropped, and one major new section was added. This was done in accordance with the calendar description of the course, and we made certain that all necessary topics were covered as required. I will also break down our grade statistics for students, both within the current year and longitudinally to that of the previous year. We have some exciting data to report regarding pedagogical research performed in the class, and have been awarded grant money to develop a concept inventory based metric against which to measure the efficacy of a planned move to Peer Instruction.

# 2 Content

## 2.1 Meeting Recap

In the spring/summer of 2018, the course coordinator (Tyler Holden) met with representatives from the Economics and Management departments. The following are the salient points from each meeting. These points have been paraphrased from our notes, and therefore should be taken as a coarse description of the meeting.

**Economics:**

- Calculus should be prioritized over that of linear algebra, and differential calculus was more important than integral calculus.

- Economics could see no immediate need for improper integrals or differential equations.
- There was a brief mention of introducing (discrete) probability with the possible goal of introducing game theory.
- Economics is not interested in implementation of a programming component to the course.

**Management:**

- Management is in the process of implementing changes to their program. This could lead to curriculum needs down the road.
- The accounting program does not have any obvious mathematical requirements other than base competency, but finance might. The finance faculty members need to be consulted.
- We should follow up with each other in a year's time to go into greater detail.

## 2.2 Content Changes

For your convenience, the calendar description of the course is given below:

> "Mathematics of finance, matrices and linear equations. Review of differential calculus; applications. Integration and fundamental theorem; applications. Introduction to partial differentiation; applications. "

The calendar description is nebulous and leaves lots of room for interpretation, in particular with regard to the various applications. Pursuant to the previous meetings, the following topics were not covered in the 2018-2019 academic year:

- Curve Sketching (Applications of differential calculus).

  Curve sketching is a useful pedagogical tool, but neither department indicated it was a necessary topic. Students were still tasked with understanding how the derivative affects the shape of a graph, but were not required to reproduce a qualitatively accurate graph of a function using these tools.
- Improper Integrals (Applications of integral calculus).

  A useful topic for applications involving long term asymptotics, but again neither department indicated it was necessary to their program. This topic is particularly confusing for students, and so its limited utility lead to it being removed.

At the suggestion of Economics, this year saw the introduction of discrete probability to the curriculum. I believe that Management may also decide that this is useful in the future. We dedicated two weeks of class time to this material, including the following topics:

- Counting principles

  Students were introduced to counting arguments, including the Basic Counting Principle, combinations, and permutations.

- First principles of probability

  Students were introduced to the notion of discrete probability distributions on finite sample spaces. This included equiprobable distributions, independent events, and mutually exclusive events.

- Conditional probability

  Students were shown conditional probability and how it relates to independent events. Bayes' Theorem was introduced and used to solve simple problems.

We will admit to being pessimistic about adoption of this material, and suspected that it would be done poorly. We were pleasantly surprised to find that students engaged very well with the material, and went beyond our expectations in terms of the learning objectives. We suspect that having material with concrete ties to reality (such as dice, coins, and gambling) increased the engagement versus more abstract studies like those of calculus and linear algebra.

In our instructor debriefing, we questioned the utility of the counting arguments. One could theoretically develop the probability portion of the class using a purely data-driven model. Hence instead of spending time discussing counting techniques, more time could be spent modelling. This is something we will discuss with the appropriate departments for the next term.

A natural question at this point might be how we managed to fit this material into our course. The removal of curve sketching and improper integrals made available 1 week of time. The other week was borrowed from the review material, on which we normally allot two weeks. There was some concern that cutting down the review material might disadvantage the students, but we have seen no evidence to support this (See Section 3).

Finally, we added determinants and eigenvalues/eigenvectors to the linear algebra portion of the course. The linear algebra curriculum had previously stopped just prior to where these topics would be naturally introduced. We felt that adding this topic would open many doors in terms of further content development and applications, such as Markov Chains and systems of differential equations. This amounted to 2 hours of material, which was borrowed from the 3 hour "buffer" we normally build into the course.

### 2.3 Emergency Cancellations

This year we had several unprecedented cancellations due to weather. As a result, several changes were made on-the-fly. This included omitting

- Consumer surplus from applications of integration.
- The Chain Rule from the discussion of multivariate calculus.

We feel that these were acceptable cuts, and did not remove from the core curriculum or students' understanding of material.

# 3 Grade Analysis

## 3.1 Tests

With the introduction of the probability/discrete mathematics section, the coverage of each term test has changed slightly. Nonetheless, we believe there is interesting information to be gleaned from the data below. All data is given as a percentage.

| | | Test 1 | Test 2 | Test 3 | Test 4 |
|---|---|---|---|---|---|
| 2017-8 | Mean | 61 | 58 | 40 | 43 |
| | Std | 22 | 25 | 24 | 32 |
| | 1st Q | 48 | 42 | 20 | 10 |
| | 2nd Q | 63 | 62 | 37 | 47 |
| | 3rd Q | 77 | 80 | 58 | 70 |
| 2018-9 | Mean | 52 | 61 | 57 | 57 |
| | Std | 21 | 19 | 19 | 22 |
| | 1st Q | 37 | 48 | 42 | 42 |
| | 2nd Q | 52 | 60 | 58 | 58 |
| | 3rd Q | 68 | 73 | 72 | 75 |

We see that 2018-19 had less overall variance in the averages across term tests, and smaller standard deviations in general. Notably, Term Test 2 is the assessment that evaluated the probability portion of new material, and was overall the best test in terms of performance.

This year, Term Test 4 saw an unprecedented 45 students claim to be ill. For comparison, this is twice the number as all previous tests combined. Term Test 4 happened to coincide with a term test with ECO100Y, and it is my belief that many students feigned illness so as to only write one of these tests. Something similar happened in the final exam (see Section 3.3).

## 3.2 Assignments

During the 2017-18 year, students were expected to submit 6 assignments over the full term. This year, as part of our pedagogical research this year, students were divided into two groups based on the parity of their student number. One group submitted assignments in the first term, the other in the second term. The averages are below:

| | A1 | A2 | A3 | A4 | A5 | A6 |
|---|---|---|---|---|---|---|
| 2017-18 | 93 | 90 | 90 | 97 | 87 | 93 |
| 2018-19A | 78 | 64 | 72 | 77 | 69 | 67 |
| 2018-19B | 66 | 58 | 74 | 67 | 60 | 55 |

Notably, assignment scores were much lower this year, which we attribute to a higher standard of marking. As CrowdMark was used this year, the marking was supervised and TAs were held to a greater standard. It is worth mentioning that this year we were able to prosecute a greater

number of academic offenses based on assignment plagiarism. Indeed, we had to pick and choose only the most egregious cases to pursue, given the incredible volume of offenses.

### 3.3 Final Exam

As of the writing of this report, an astounding 70 students had deferred the final exam. We strongly suspect this is due to the timing of the exam. Classes ended on Friday, April 5th. The MAT133Y5 exam was written at 9am on Tuesday, April 9th, and the ECO100Y5 exam was written at 1pm on Wednesday, April 10th. Both classes are full-credit courses, notably difficult courses, and occurred at the beginning of an exam period with an unusually short respite from the end of the term. Given the overwhelming overlap in enrollment between the two courses, we suspect students feigned illness in one class in order to properly prepare for the exam.

We have written to the Office of the Registrar about this, and have been in talks with them to avoid such scheduling issues in the future.

| | Mean | Std | 1st Q | 2nd Q | 3rd Q |
|---|---|---|---|---|---|
| 2017-18 | 56 | 22 | 40 | 58 | 71 |
| 2018-19 | 56 | 20 | 42 | 58 | 71 |

We see here that the performance on the final exam this year near perfectly imitates that of the previous year.

## 4 Delivery

This year saw the first use of Crowdmark in administering both term tests and assignments in the course. The program was incredibly successful. A notable side-effect was a significant increase in the number of academic offenses that were discovered and prosecuted. Interviews with these students revealed that most students were unaware that what they were doing constituted an academic offense. This includes

- Posting to/copying from images posted to large online group chats,
- Copying answers from a friend who presents the solutions.

This suggests we need to take greater action in the future in explicitly addressing these issues.

Another interesting facet this year was the implementation of an offset assignment submission system. Here the class was divided into two groups, with one group required to submit assignments in the fall, and the other in the winter. See Section 5 for more information on the reasoning why, and results behind this experiment.

# 5 Pedagogical Research

This year MAT133Y5 was part of a pedagogical research project, designed to quantify the effect of the assignments on student learning. Students were divided into two groups: Group A were those students with even student numbers, while Group B consisted of those students with odd student numbers. Group A students were required to submit assignments in the fall term, but not in the winter. Conversely, Group B students submitted their assignments in the winter term, but not in the fall. All students had full access to every assignment, full solutions and the grading rubric to every assignment was made available immediately after the due date.

The use of CrowdMark ensured a higher standard in TA marking, and facilitated detailed feedback on their assignments. Students were also told that term test questions would heavily related to material found on the assignments. The following is the tentative data that was found:

| | | Test 1 | Test 2 | Test 3 | Test 4 | Final |
|---|---|---|---|---|---|---|
| Group A | Mean | 53 | 61 | 53 | 47 | 56 |
| | Std | 22 | 21 | 24 | 27 | 20 |
| | 1st Q | 38 | 50 | 30 | 38 | 42 |
| | 2nd Q | 53 | 63 | 57 | 51 | 57 |
| | 3rd Q | 70 | 75 | 70 | 67 | 72 |
| Group B | Mean | 47 | 55 | 54 | 52 | 57 |
| | Std | 23 | 22 | 22 | 29 | 20 |
| | 1st Q | 29 | 42 | 40 | 31 | 42 |
| | 2nd Q | 47 | 57 | 57 | 58 | 59 |
| | 3rd Q | 63 | 70 | 70 | 75 | 70 |

Note the near identical performance on the final exam, with variation in the term test performance.

Naturally, the Test 3 and Test 4 data must be taken with a grain of salt, given that the switch between terms would have compromised the control group. However, what we see here is a strong indication that being required to submit assignment did make an impact on test scores, with that number being between 5 and 6%. This is not a trivial difference. However, 47% of our course resources were allocated to marking assignments, and we should keep in mind that this is a reduced number of marking hours, given that only half of the class submitted assignments at any given time. There is evidence here to suggest that investing so heavily in assignment marking may not be worth that 6% gain.

# 6 Future Plans

## 6.1 Curriculum

Subject to subsequent meetings with the Economics and Management departments, we are looking at further curriculum changes on the horizon. If this experimental venture into discrete probability is approved by those departments, we will look into further development of this content. This may

include an expansion of the topics covered, or including continuous probability – a natural application of calculus. This may require cutting other material. At this moment, neither department has indicated a need for Ordinary Differential Equations, and so this material is currently the lead material to be cut from the course.

### 6.2 Structure

Curriculum changes aside, our long term goal for this course is to implement a modified form of Peer Instruction (PI) as the primary instructional medium. Peer Instruction is a form of inverted classroom, whereby students are responsible for acquiring the knowledge outside of the classroom, and lecture time is spent grapsing a conceptual understanding of the material. To this effect, we will create a series of approximately 200 videos of 6-10 minutes in length, which students will watch prior to coming to class. Classroom time will consist of multiple choice questions offered through an open source classroom response system, and problem solving sessions. Video creation will be taking place from December 2018 - August 2020. Our timeline is either full-scale implementation of this project for the Fall 2020 academic year, or partial implementation for Fall 2020 with full-scale implementation by Fall 2021.

In January, we were awarded a Teaching Development and Innnovation (TDI) grant for $5000. The purpose of this grant is to fund the creation of a Concept Inventory (CI) based metric for measuring teaching interventions in MAT133. Work on this will commence in April 2019, with the first draft ready by October 2019. Validation interviews will be held in November 2019, with tests and statistical analysis occuring shortly thereafter. The 2019-2020 academic year will therefore serve as a baseline for comparison against the inverted classroom implementation the following year. However, this is subject to a focused deadline and is not amenable to set backs. It may therefore be necessary to push deployment of the CI and PI one year later than planned. We are looking to involve the St. George campus in this project as well, but leadership of MAT133 is currently in flux.

Over the course of the year, we noticed students with fundamental gaps in secondary school knowledge. This included everything from a misunderstanding of fractions and simple number facts, to confusion regarding both abstract and transcendental functions, such as logarithms. We aim to remedy this by means of the Numeracy Development Initiative (NDI) fund, to which we are currently in the process of applying. If granted, the fund would subsidize a set of workshops that would run parallel to but separate from MAT133Y5, with the idea using a just-in-time teaching framework for reviewing fundamental numeracy issues just prior to the appropriate subject. For example, this would include logarithms and exponentials prior to covering financial mathematics, algebraic manipulation and fractions prior to linear algebra, and functions prior to starting the calculus component. We are optimistic about our funding opportunity.