

Introduction

The University of Rochester has three different calculus sequences for students to choose from. We will refer to these sequences as Calculus X, Y, and Z. All three sequences cover all of the standard material from single variable calculus. Calculus sequence X is the most advanced sequence, designed mainly for math majors. This sequence is almost entirely proof based, and this project does not look at this sequence. Calculus sequence Y covers all of the material in two semesters. Many of the students in this sequence are either engineering or science majors. Calculus sequence Z covers all of the same material as sequence Y (and also uses the same textbook), but at a slower pace. Sequence Z takes three semesters to complete instead of two. This sequence is intended for students without a strong mathematics background. The hope is, that at the end of either sequence Y or Z, students will be equally prepared to continue on in math, science, or engineering classes. However, recent tests and professor observations have indicated that students who have completed sequence Z are less likely to perform well in other science and engineering classes than students who have completed sequence Y.

Objectives

The main objective of this project is to identify some of the differences between the students in sequence Y and sequence Z, to gain a better understanding of why one sequence seems to prepare students better for more advanced classes. This project has two main parts:

One part looks at the mathematical backgrounds of the students. In particular, we look at the highest level of math that each student has taken previously. My hypothesis is that some of the students may be underprepared for the class that they are taking. Both sequences assume a solid grasp of algebra and trigonometry concepts. Students lacking a strong background in either topic are likely to fall behind and be less successful in both the sequence and future courses.

The other part of the project tests each student's ability to answer "nonstandard" calculus questions. These questions are more abstract than students in either sequence would see in class, on homework assignments, or on exams. The questions are designed to require minimal (if any) computation. Each question tests the student's understanding of a key concept in the class.

Methods

The students who participated in this project were all at the end of the first semester of either calculus Y or calculus Z. When this project was implemented, both classes had covered all of the necessary material to answer all of the calculus questions asked in this project.

All students in the first semester of calculus Y or Z were sent an e-mail asking them to participate in two surveys. The first survey asks questions about the mathematical backgrounds of the students, and the second "survey" asks students to answer several calculus questions.

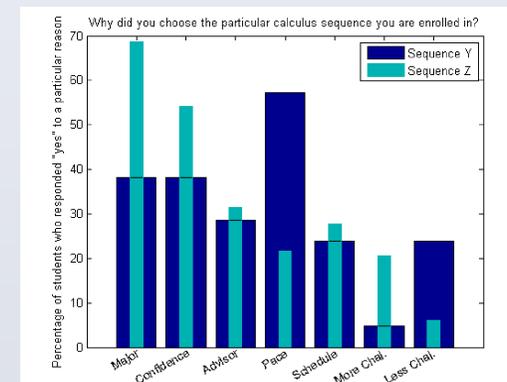
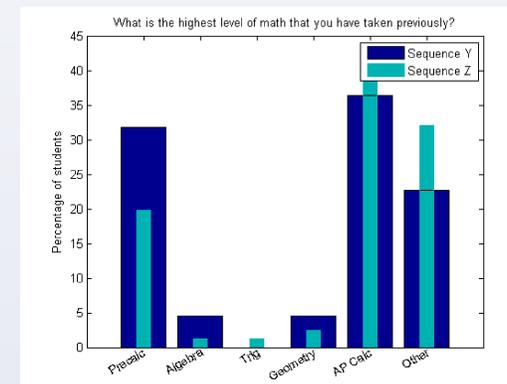
Questions on Survey 1:

- What is your age group?
 - Under 18
 - 18-25
 - 25-40
 - above 40
- What is the highest level math course that you completed prior to taking this course?
 - Precalculus
 - Algebra
 - Trigonometry
 - Geometry
 - AP Calculus
 - Other (please specify)
- How long has it been since you last took a math course?
 - Less than 1 year
 - 1-5 years
 - Greater than 5 years
- Did you attend high school in the United States?
 - Yes
 - No
- When choosing which calculus sequence to take, why did you choose this sequence? (e.g. Y instead of Z or vice versa). Check all that apply.
 - This particular course is needed for the major I am currently pursuing.
 - My confidence level in my mathematical ability.
 - My advisor recommended this course based on my mathematical background.
 - I prefer a slower/faster paced math course.
 - This course fit into my schedule best.
 - Wanted a challenge.
 - Wanted a less challenging course.
- Please provide us with any other feedback about why you chose the course you are enrolled in.

Questions on Survey 2:

- Which calculus sequence are you currently enrolled in?
 - Sequence Y
 - Sequence Z
- Find a number "k" such that if $|x-2|<k$, then $|4x-8|<e$, where $e=0.1$. (Open-ended question. No answer options given.)
- If we know that $f(a)=b$ and $f'(a)=c$, then what is $d/dx (f(x)/x^2)$ evaluated at $x=a$? (Open ended question. No answer options given.)
- You decide to estimate e^2 by squaring longer decimal approximations of $e=2.71828\dots$
 - This is a good idea because e is rational.
 - This is a good idea because $y=x^2$ is continuous.
 - This is a bad idea because e is irrational.
 - This is a good idea because $y=e^x$ is continuous
- We know that $\lim_{x \rightarrow 0} \sin(x)/x=1$. This means that:
 - $0/0=1$
 - The tangent to the graph of $y=\sin(x)$ at $(0,0)$ is the line $y=x$.
 - You can cancel the x 's.
 - $\sin(x)=x$ for x near 0
 - All of the above.
 - None of the above.

Results of Survey 1

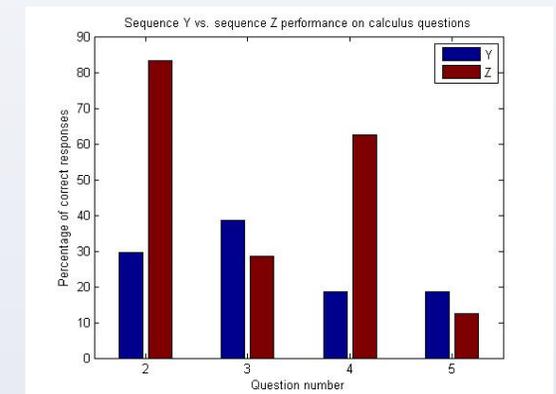


For space considerations, these are the two questions that I chose to show results for, as they told us the most about what we were looking for. Results for all other questions were analyzed, but answers did not vary much from class to class. Of the students who answered "other" for their most recent high level math class, the most common responses were either statistics or calculus (but not advanced placement calculus).

The results of survey 2 surprised us more than the results of survey 1. The students from sequence Z (the slower sequence) actually performed better than the students from sequence Y. This is likely due to the fact that the response rate from sequence Z was much lower than that of sequence Y, so it is possible that only the top students in sequence Z responded.

Also worth noting is that not one student from either sequence answered all of the questions correctly. This leads us to believe that the questions need more development.

Results of Survey 2



Direction for Future Study

There were several problems with this study that came to light as soon as we saw the results:

- We did not get enough participation in the study for students in sequence Z. We had 26 participants from sequence Y and only 9 participants from sequence Z. Ideally, we would like more participation from both.
- The calculus questions asked may have ended up being too difficult for students, regardless of the sequence they were enrolled in. There were no students who answered all questions correctly, while almost 1/3 answered all questions incorrectly.
- The study did not highlight material where there was a significant gap between the students in Y and Z.

Possible solutions for a follow up study:

- Offer an incentive to students for participation.
- Develop a wider range of calculus questions and test them on a small focus group of students first.
- Link survey on mathematical background with responses to calculus questions.

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