

# Enhancing Online Calculus to Include Flipped Elements

Daniel James  
Department of Mathematics

## Background

MATH 126 is the second of the three courses in the STEM calculus sequence and serves as a prerequisite or co-requisite for courses taken by students in majors across the College of Liberal Arts and Sciences and the School of Engineering. Students enroll in both a lecture section (containing 100-250 students) and a lab section (containing about 30 students).

The course can be divided into three primary units:

- Techniques and Applications of Integration
- Infinite Series
- Parametric Equations, Polar Coordinates, and Vector Geometry

A typical MATH 126 student has a good grasp of techniques of differentiation and at least some familiarity with integration, but very limited experience with series or even associated notation. Consequently, the unit on infinite series is typically quite difficult for students to grasp conceptually in the same way other topics in the course can be grasped. This hinders student success both in MATH 126 and in courses downstream.

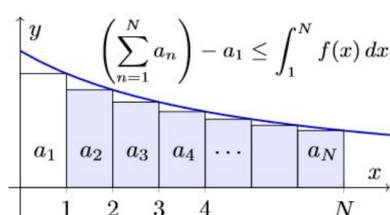


Figure 1: Initial unfamiliarity with infinite series notation can obfuscate learning goals for many MATH 126 students.

## Objectives

In this transformation, I sought to improve instruction in the series unit by:

- Making learning goals clear, accessible, and consistent
- Redesigning assessments to be more conducive to demonstration of learning and
- Provide feedback to move learners forward.

## Implementation

Three primary transformations were designed for and implemented during the Spring 2021 semester.

### 1. Pre-lecture Video Quizzes

Pre-lecture video quizzes beginning with a statement of learning goals were made for each topic in or preceding the series unit to create time in lectures to accommodate more active learning opportunities.

### 2. Learning Goal Activities (LGAs)

[Written homework assignments](#) clearly stated learning goals followed by 3-5 tasks on which students could demonstrate achievement of those learning goals. This allowed for error pattern detection.

### 3. Enhancing Feedback Quality

GTAs engaged in [weekly activities](#) enhancing their abilities to perform error analyses of student work and to anticipate student mistakes. Graders were provided with [feedback forms](#) to enhance feedback provision.

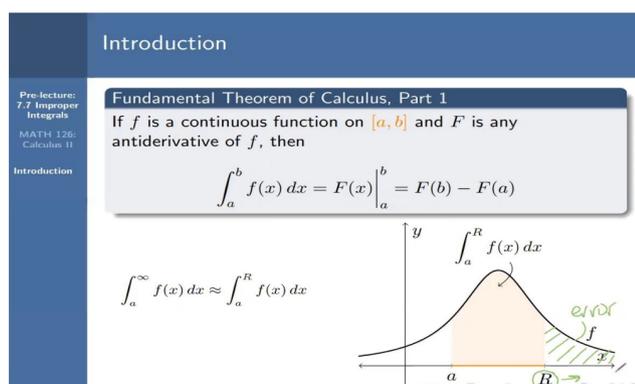


Figure 2: Click [here](#) to view a pre-lecture video quiz. This video quiz covers material needed to make sense of the infinite series.

## Student learning

### KEY RESULT

After controlling for scores on a prerequisite skills test, midterm exam scores increased by an average of approximately 28 points (out of 100) from Fall 2020, with the biggest gains made by student groups whose prerequisite skills test score put them at high risk of failure based on data from Fall 2020.

### Analysis & Results

Students in MATH 126 during Spring 2021 were matched with students from Fall 2020 based on their prerequisite skills test score (out of 20) via propensity score matching to control for ability level.

Matched students' performances on the midterm exam (out of 100) covering the infinite series unit were then compared to detect a difference in exam scores between Fall 2020 and Spring 2021.

The estimated average change in midterm exam score was 28.148 points ( $p < 2.22 \times 10^{-16}$ ). The largest increases were seen in groups corresponding to prerequisite test scores correlated with a high DFW risk during the Fall 2020 semester.

### Student Feedback

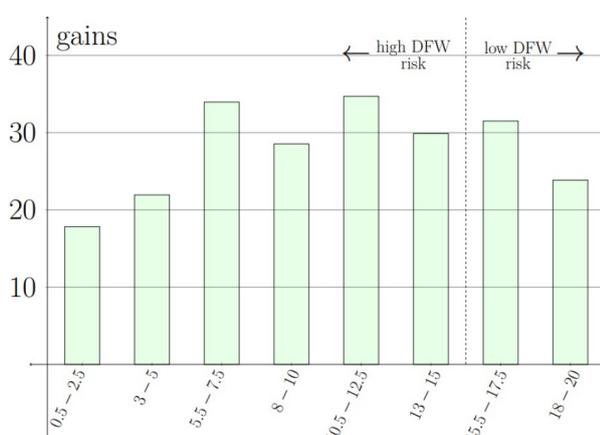
Students provided unsolicited feedback about the course transformations, particularly the pre-lecture video quizzes:

"The way you structure class between pre-lecture, Webassign, LGA's, it makes it so by the time the test comes around I have an intuitive understanding or at least I'm on that track."

"Having the learning goals helps me see how to get started."

"I also just wanted to say I appreciate . . . the great pre-lecture videos. We students recognize your effort and we appreciate it :)"

Midterm Exam Score (/100) Gains by Pre-req Skills Test Scores (/20)



## Reflections

Transparency and clear objectives are known to disproportionately benefit demographics typically at higher risk of failure to graduate. Including learning goals in formative assessments will be a standard practice in my instruction in future semesters.

The most common student complaint about the video quizzes was that they could not attempt them more than once—a technological limitation. Video quizzes could be enhanced by allowing multiple submissions.

GTAs and undergraduate graders play a vital role in lower-level undergraduate mathematics instruction. Supporting them as educators is of critical importance in mathematics instruction.

Performance in spring semester MATH 126 tends to be stronger than in fall semester MATH 126. Although the prerequisite skills test was kept consistent across semesters, having other data to incorporate into propensity score matching would strengthen the results.

*Acknowledgements: Thanks to my instruction team for their help this semester, and thanks to my husband for sharing his statistical expertise!*