Project Name

A Hybrid Approach for Teaching Calculus

Principal Investigator James M. Pitarresi

Campus Binghamton University

Year of Project 2013

Tier Tier Two

Project Team

- Laura Anderson, Binghamton University
- Joseph Brennan, Binghamton University
- Daniel McKinney, Binghamton University

Overview Summary

Calculus hybrid and flipped module development to support best practices, employ a pre-calculus screening exam for early identification and focused remediation for students with weak skills, and creation of targeted tutorials to keep students "on-track"

Project Abstract

Each year, the Department of Mathematics at Binghamton University teaches Calculus I to more than 1,000 students. The satisfaction and overall performance of students in this course is often poor, consistent with other large gateway courses taught at universities nationwide. This poor performance can lead to students dropping their intended major or continuing through the curriculum with weakened skills and negative attitudes toward math, which has a serious “domino effect” on core subjects in their major. Given the critical role of mathematics in many majors, finding new, more effective approaches to ensure student success in this gateway course is critical.

In this innovative project, we in the Department of Mathematics and the Watson School of Engineering and Applied Sciences have joined to focus on a powerful combination of approaches to tackle this teaching and learning problem. Specifically, we plan a three-pronged method: (1) implement a flipped classroom approach

for Calculus I, (2) employ the pre-calculus screening exam that all students need to take prior to enrolling in Calculus I to help identify students with weak skills, (3) develop focused remedial tutorials in conjunction with regular math skills testing to both address areas of student weakness and to keep students “on-track” during the semester.

The essential idea behind the flipped classroom is to use precious face-to-face class time for student-centered learning, not rote information transfer(1). Technological advances, let alone the rapidly changing ways in which today’s students gather and assimilate information, make the information transfer part of the “teaching” the least effective ways to use class time. In the strictest sense, a flipped classroom has all the information transfer occur outside the classroom and class time is reserved for problem solving. In the hybrid-flipped classroom, a judicious blend of in and out of class information transfer coupled with a consistent and significant amount of in-class time devoted to team-based and individual problem solving not only improves student learning but helps address a wider range of student learning styles.

We propose to run, in Fall 2013, a Calculus I pilot project for the Watson Engineering students that encompasses a number of features. The Math Department will identify those students who scored lowest on the required pre-calculus exam and enroll them in special sections of Calculus I with additional remedial help more tailored instruction, while the higher-scoring students will populate the remaining Calculus I sections reserved for Watson students. Two of the three sections with lowest-scoring students as well as four or five of the other sections will be taught as flipped classrooms; the remaining sections will be taught in the traditional lecture style. The students in all sections will take the same exams. Thus the project will provide information about whether students learn better in flipped classrooms, and whether offering more tailored/flexibly-paced instruction and remedial materials helps low-scoring students. The proposed pilot project will involve only students from the Watson School—if the project is successful, then the Department of Mathematics will explore whether the approach can be extended.

To facilitate our planned delivery of the pilot project for Fall 2013, the summer of 2013 will be occupied with developing the content for the flipped lectures (i.e., “chunking” the curriculum). This will be done by Laura Anderson and Joe Brennan from the Math Department and James Pitarresi from the Engineering School. They will record short and focused “chunked” video segments and mini-assessment problems that students will watch prior to coming to class, that is, as part of their homework, thereby freeing class time for collaboration and meaningful problem solving exercises wherein students (individually and in teams) practice the theory. For our hybrid-flipped classroom, certain topics will be taught in the traditional way as, frankly, sometimes an interactive presentation and derivation is the best way to learn. However, the vast majority of the material will be flipped. Along with the chunking of the curriculum and development of the video mini-lectures, there is also a need to offer a workshop on flipped classroom teaching methods and time management for the calculus instructors, which will be facilitated by James Pitarresi in Summer 2013. Finally, additional remedial materials will be developed by Dan McKinney, Joe Brennan, and Laura Anderson that will be used to supplement the learning for those students that had weak scores on the screen exam.

We also plan to provide extensive assessment data of the flipped and non-flipped sections as all sections will take same tests, so we will have many opportunities to compare teaching approaches. Specifically:

1. To assess how well students are gaining basic competency, we have the Skills Tests(2) .
2. To assess more advanced computational/problem solving competency, we have two midterms and a final exam. (The tests aren’t completely problem-solving, but we can easily plan on separating out that part of the grade.)
3. To assess conceptual understanding, we will use the Calculus Concept Inventory (CCI)(3), administered at the beginning and end of the semester. This is a standardized multiple-choice test being used in many assessments of calculus reforms.
4. Student opinion surveys to assess student attitudes and feedback for future improvements.

We will also compare students from several cohorts: students who have/haven’t previously taken a Calculus

course, students with strong/weak grades on our pre-calculus Screening Test.

This project is very promising and well worth the resources that the Math Department and the Watson School are requesting for several reasons. First, the model of a flipped classroom puts much emphasis on student collaboration and on examples, both of which are likely to be of particular benefit to the students who struggle most in calculus. Second, the set-up of the pilot project makes it straightforward to assess whether or not the flipped classroom delivers on its promises, because both groups—the weaker as well as the stronger students—are taught in flipped as well as traditional classrooms and all students take the same exams. This will make it straightforward to assess whether extending the pilot project would be worthwhile. Third, the project makes use of the existing expertise of James Pitarresi, who has accumulated considerable teaching experience with flipped classrooms for several years. Thus one can expect that tapping this resource will permit the Department of Mathematics to avoid some of the start-up errors that are usually inevitable with projects that constitute considerable departures from established teaching practices. Fourth, if the project is successful, then it can serve as a model for other schools that seek to improve their practices of teaching calculus to engineers.

(1) Flip the classroom - http://donaldclarkplanb.blogspot.com/2011_03_01_archive.html
(2) http://www.math.binghamton.edu/calc1/
(3) http://www.flaguide.org/tools/diagnostic/calculus_concept_inventory.php

Reports and Resources

- Project article
- Project website
- Mid-project report
- Project outcomes report
- Project outcomes report 2.0

Discipline Specific Pedagogy

- STEM

Instructional Design

- Student Learning Support

Instructional Technologies

- Open Educational Resources (OER)