

Revolutionizing Calculus at the University of Minnesota

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Abstract: The University of Minnesota office of Special Projects has just completed piloting a three quarter calculus sequence designed for the average calculus-ready incoming Institute of Technology freshmen. The first round of data collection has just been completed and the results obtained so far show a successful course that is ready to expand. A description of the course and the results are presented. A manuscript with more details will be available in the near future.

Math 1351/1352/1353

Calculus: Explorations and Applications

Textbook. The text used is *Calculus from Graphical Numerical and Symbolic Points of View* by A. Ostebee and P. Zorn, a high level reform text which includes formal definitions, theorems and proofs, and the $\epsilon - \delta$ definition of limit. Emphasizing conceptual and geometric reasoning, it is written at a level that students can, and are expected to, read and understand before going to lecture. At the same time, this text provides an excellent reference for the stronger student to extend his or her knowledge of the subject.

Format of Lecture. Twice a week, all 100 students attend a one hour large lecture taught by a professor, with two workshop instructors present. In addition to discussing new material, the professors have the students work in small groups on problems during the hour, with the workshop instructors helping the students. The primary purpose of the lectures is to provide initial contact with the new concepts, or the give theoretical justifications for the concepts introduced in the workshop the previous day.

Format of Workshops. Meeting three hours per week, there are two workshops of 25 students each, each facilitated by a workshop instructor. Lesson plans are the same for all four workshops, ensuring continuity. A professor is present in one workshop session to help facilitate the workshop's activities. Some workshop activities are set at a level commensurate with the medium homework problems, designed to allow the students to discover advanced concepts for themselves, and to practice working with these concepts. Other workshop activities foreshadow future sections, or the next day's lecture. These are designed to give the students and the lecturers useful examples to refer to later, and to give the students a chance to develop computational expertise for upcoming theory.

Format of Labs. Four times during the first year, the students work through a large scale application of what they have learned so far. They are put into teams of three or four, and given class time to work on them, although it is understood that significant time will be spent out of class. The students are given hard-copies of the project, and have one workshop meeting in a computer lab. In addition to learning some non-trivial mathematics, the students are also forced to allocate labor, oversee quality, and make design decisions when writing their group report.

Gateway Exam. Students may not receive a grade for calculus until they have proven their ability to compute derivatives (first quarter) and integrals (second quarter). The students are given an exam, which they must retake until they achieve a grade of 80% or better.

Restructuring. Student feedback is elicited at various times throughout the course, and good concrete suggestions are acted upon rapidly by the staff. Administrative details such as due dates, office hours, and allocations of time during the workshops and lectures have been modified to maximize student learning.

Population. In the Fall of 1996, there will be two 100 student sections of Math 1351. Of the original 100 who took Math 1351 in the Fall of 1995, 65 of them completed the third quarter course with a grade of C or better. There are 67 students enrolled in the fourth-quarter course, Math 3354, 57 of them being from the original 100 Math 1351 students. Math 3354 will have a similar structure to Math 1351, except that there will be a laboratory application every week.

Slides:

Enrollment in the First Year

Math 1351 :	97 Students	(79 M,	18 F)
Math 1352 :	78 Students	(64 M,	14 F)
Math 1353 :	68 Students	(58 M,	10 F)




Enrollment in the second year

Math 3354 :	58 Continuing	(51 M, 7 F)
	5 Returning	(3 M, 2 F)
	~5 New to program	

The Lectures Include:

- Initial exposure to difficult concepts
- Discussion of concepts from book in applied contexts
- ✱ Theoretical justification of concepts introduced previously
- ✍ Guided student practice of new material

The Workshops Include:

- ↔ Expansion of concepts from previous afternoon's lecture
-  Skill practice for homework, and gateway exams
-  Foreshadowing of and preparation for future material
-  Initial computer time for laboratory projects.

The Labs Include:

- ◆ Real applications from engineering and science
- 🔧 An opportunity to run experiments and form conclusions
- 📱 A stratified and modular approach
- 📖 Problems that implicitly require the use of calculus

The Wish List

- ✓ Ability to do computations
- ✓ Ability to write
- ✓ Ability to work in groups
- ✓ Ability to work independently
- ✓ Ability to explore (play)

These were the students that we ideally would have liked to enter our course. An unexpected side effect of the course was that, by the third quarter, this list described our students perfectly.

Group work in the velocity experiment
(part of the Numerical Integration Lab)

-] One student drives
-] One student calls out speedometer data
-] One student records speeds and times
-] All students plan collection strategies
-] All students use the web-site to compute an estimate of distance traveled.

What the students found important
(Spring data)

“How much did the _____ contribute to your overall learning?”

	(Very) Much	(Very) Little
Workshop Activities:	86 %	2 %
Lecture Activities:	63 %	11 %
Interaction with Classmates:	81 %	7 %

The Homework

"The amount of homework was appropriate for the course"

	(strongly) agree	(strongly) disagree
Fall Quarter:	48 %	24 %
Winter Quarter:	81 %	6 %
Spring Quarter:	91 %	2 %

"How useful were the homework assignments?"

	(very) useful	(limited) not useful
Fall Quarter:	47 %	17 %
Winter Quarter:	83 %	4 %
Spring Quarter:	76 %	2 %

The Homework

"The text had challenging problems"

	(strongly) agree	(strongly) disagree
Fall Quarter:	93 %	0 %
Winter Quarter:	91 %	4 %
Spring Quarter:	90 %	2 %

"On average, I did __ hours of homework and studying per week"

Average

Fall Quarter:	7.84
Winter Quarter:	5.94
Spring Quarter:	4.4

Our Learning Curve

"The workshop instructor increased my interest in Mathematics"

	(strongly) agree	(strongly) disagree
Fall Quarter:	63 %	9 %
Winter Quarter:	70 %	0 %
Spring Quarter:	80 %	2 %

"The faculty instructor increased my interest in Mathematics"

	(strongly) agree	(strongly) disagree
Fall Quarter:	56 %	10 %
Winter Quarter:	60 %	10 %
Spring Quarter:	73 %	2 %

Course Grades

	A	B	C	D	F / W
Math 1351:	43%	43%	10%	1%	2%
Math 1352:	42%	50%	8%		
Math 1353:	43%	32%	19%	1%	4%

Location of computer modules:

<http://www.geom.umn.edu/locate/lab>

For more information contact:
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