Teaching Methods Comparison in a Large Introductory Calculus Class

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Motivation

- Hake (1998). **Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses**. *American Journal of Physics*.
- Deslauriers, Schelew and Wieman (2011). **Improved Learning in a Large-Enrollment Physics Class**. *Science.*
- Can we do this for Calculus?

Setting

- Math 104: Differential Calculus for Business and the Social Sciences
- 1st Term, 1st Year Course
- 95% of students in this course have taken a calculus course prior to university.
- Two sections, 150 and 200 students, good instructors.

The plan

1. Establish two comparable sections.
2. Junior instructor trained in research-based methods takes over for one topic (100-150 minutes of in-class time) in each section.
3. Compare student responses on quizzes, midterm and final exam questions for both topics.

Experimental Design

Course weeks →								
Section A								
A_1	A_2	$A_3 \ldots$	A_7	$\mathbf{X_8}$	A_9	A_{10}	A_{11}	A_{12}
Section B								
B_1	B_2	$B_3 \ldots$	B_7	B_8	B_9	B_{10}	$\mathbf{X_{11}}$	B_{12}
Assessments in common								
att	D			Q_{RR}	M_{RR}		Q_{LA}	att	FE

att: MAPS attitude survey (see poster), **D**: diagnostic pre-calculus and calculus tests, $\mathbf{Q_{RR}}$: Related Rates quiz, $\mathbf{M_{RR}}$: Midterm (Related Rates), $\mathbf{Q_{LA}}$: Linear Approx. quiz, **FE**: common final exam

Instructional Methods

Standard week: **Lecture with questions**

- Chalkboard lecture
- Clicker questions
- Whole-class discussions led by instructor

"Intervention week": **Higher engagement**

- Pre-class assignment
- In class:
    - Structured handout
    - More clicker questions
    - Small group tasks

Captured by *Teaching Dimensions Observation Protocol*

Teaching Dimensions Observation Protocol

Inst	5-min Slices	Admin	Lecture: theory	Lecture: example	Lecture: interactive	Student Tasks	Clicker Q	Q from Student
A	72	6.3%	29.5%	23.5%	18.4%	2.1%	3.6%	16.5%
B	109	6.6%	22.3%	36.3%	18.0%	0.0%	1.0%	15.9%
X	39	5.1%	20.6%	21.3%	20.1%	10.7%	16.9%	5.4%

Table 1: Average number of 5-minute slices containing described activity (slices can contain more than one type of activity) for each of the instructors.

Admin: classroom announcements, hand out/collect paper.

Lecture: new item: Instructor presents new material/theory/ideas.

Lecture: example: Instructor presents worked example.

Lecture: interactive: Instructor leads classroom discussion by posing questions to students with responses/replies.

Student Tasks: Students are directed to work alone or in groups on a task,

Clicker Question: Instructor poses in-class voting question (multiple choice), students given time to think/discuss and choose response.

Q from Student: Student asks question, instructor responds.

Research Questions

1. Will students demonstrate more sophisticated reasoning on an immediate test of learning?

2. Will any effects persist to later, more standard tests of learning in the course?

Measurement

Series of assessments:

- Quizzes in class at end of each topic.
- Common midterm problem (one topic).
- Common final exam problems.

Goals for the assessment:

- Problems typical in the course.
- Expose student thinking: concepts and computation.

Related Rates

Concepts

- constant vs. changing quantities
- 3D shapes

Computation

- Implicit differentiation technique
- Derivative rules

Cones and Cylinders

Filling inverted cone and cylindrical tanks of equal volume, adding water at same rate.

Linear Approximation

Concepts

- Goal of the process
- Interpreting error
- Relate graph/picture to the formula

Computation

- Use of the formula
- Derivative rules

Results for experimental section:

On immediate assessment of learning:

- Higher performance on *conceptual* items.
- Similar performance on *computational* items (which depend more on earlier course components).

On later assessment:

- Effect present on second, standard assessment.
- Third assessment of Related Rates topic (final exam) not significant.

Student Performance

- Key results from our assessments are summarized in Tables 2 though 6.
- Tests of significance for the proportions of students demonstrating a specific skill, either in a binary fashion (a row with its own p-value) or in a set of mutually exclusive categories (multiple rows with single p-value).
- Excluded students who were not present for the instruction (who did not write a quiz) from our analysis; this was a considerable number for the second intervention week due to an external event.

Work in progress

- Comparison with other topics on final and with other sections.
- Validation interviews for assessment items.
- Track student learning through term, incorporate attitude data.