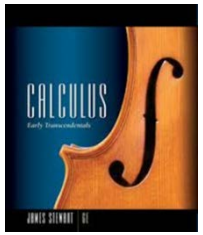
Lessons Learning in Online, Hybrid and Flipped Teaching in STEM

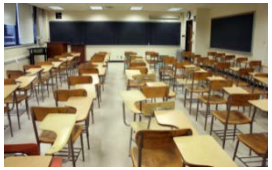
Sarah E. Eichhorn
Associate Dean, Distance Learning
University of California, Irvine

UCI Math Instructional Experiments



1. Calculus Course Coordination

2. Online Pre-Calculus Course



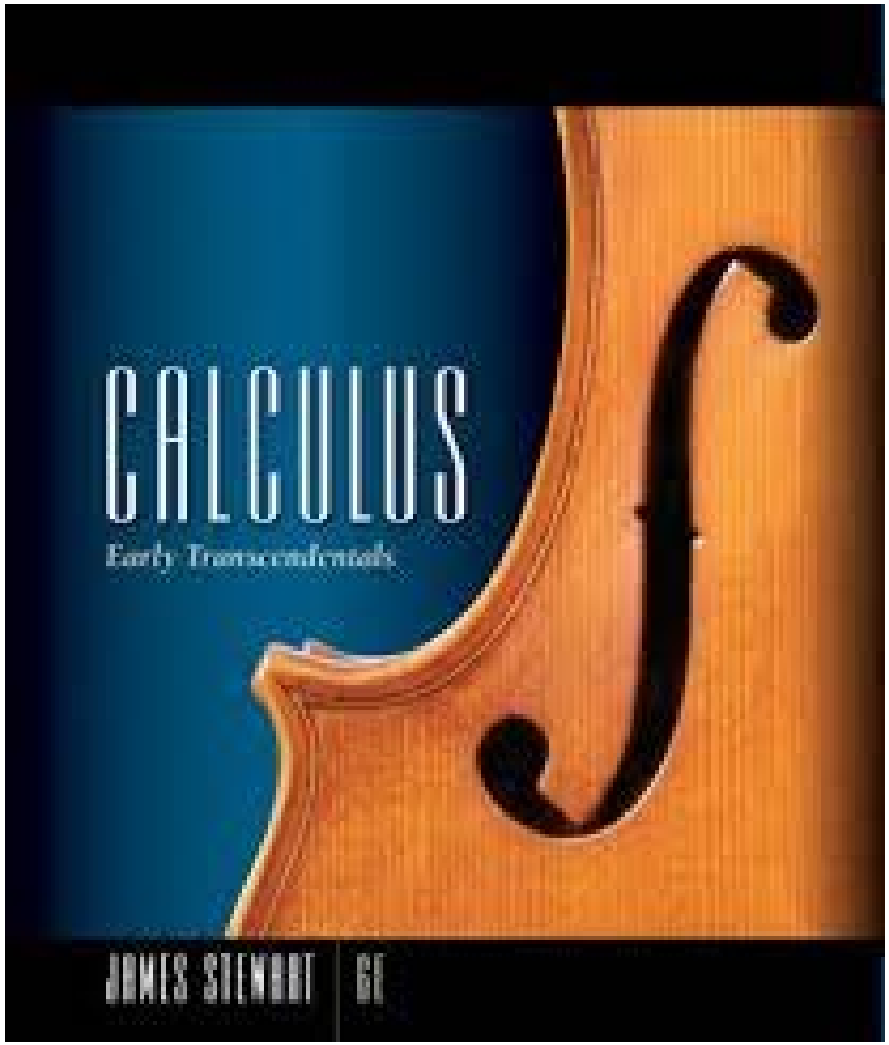
3. Flipping the Calculus Classroom

UCI General Lessons Learned

4. Best Practices

5. Simple Innovation Starting Points

1. Calculus Coordination



UCI Calculus by the Numbers

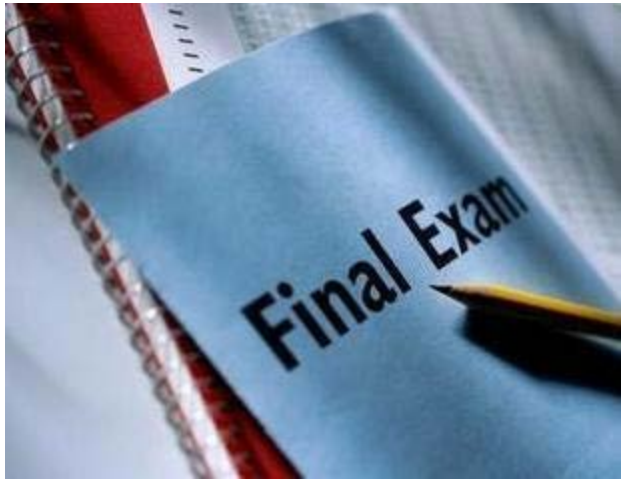
- 2 quarters of Single Variable Calculus
  - 2A: Limits and Differentiation
  - 2B: Integration
- 120 or 240 students per section
- ~ 10 sections of each course per quarter
- ~ 2,500 students per quarter
- ~ 8,000 students per academic year
- Instructors: 50% lecturers, 25% postdocs/VAPs, 25% ladder rank faculty

Motivation for Course Coordination

- Ensure that all students are taught and responsible for material at the same level of rigor and are similarly prepared for subsequent math courses
- Help unify grading across different sections of the courses, ensure a fairer grading system for all students, not dependent on particular section enrollment
- Help the math department assess and redesign the Calculus courses to help aide student learning
- Create more efficient administrative procedures for instructors

Calculus Course Coordination Components

- Common final exam
- Common syllabus and grading policy
- Common textbook
- Common website with sample exams, study aids, course information, etc.
- Common online homework assignments in WeBWorK



- Some interesting findings…

After just one quarter of coordination, the student performance variation between sections was dramatically reduced.

Quarter	Course	Average Range	Range Width
Spring 2010	2A	60.46 – 73.73	13.27
Spring 2010	2B	48.55 – 61.48	12.93
Fall 2010	2A	63.26 – 67.88	4.26
Fall 2010	2B	72.03 – 78.39	6.36

The “mega” classes performed as well as smaller classes. The instructor is a bigger factor in student success than class size.

(Mega Class Avg. Final) – (Total Avg. Final)	Avg. Student Evaluation of Instructor (out of 4.0)
3.37	3.71
-2.45	3.28
2.45	3.64
0.88	3.82
7.50	3.76
5.55	3.70
2.50	3.68
-0.74	3.72
1.70	3.75
-1.44	2.62

We were not teaching proper mathematical notation well.

- Find $f'(x)$ for the function $f(x) = x^2 + 3x - 5$ using the **definition** of derivative.

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Students are “learning” algorithmic approaches to problems, rather than conceptual understanding.

- A rocket that is launched vertically is tracked by a radar station located on the ground 3 miles from the launch site. What is the vertical speed of the rocket at the instant that the rocket is 5 miles from the radar station if the distance between the rocket and the radar station is increasing at a rate of 5000 miles per hour?

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It is a rocket problem!

- A model rocket is fired vertically upward from rest. Its acceleration for the first three seconds is $a(t) = 60t$, at which time the fuel is exhausted and the rocket becomes a free falling body. At what time does the rocket hit the ground?

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Students are not retaining or able to apply material from algebra.

How do you simplify x^3x^2 ?

$$x^2x^3 = \begin{cases} x^5 & with\ p = .60 \\ x^6 & with\ p = .35 \\ x^9 & with\ p = .05 \end{cases}$$

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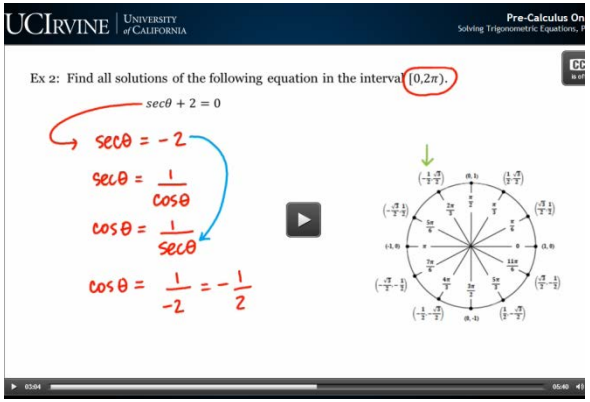
2. Online Pre-Calculus Course

Motivation for Online Pre-Calculus

- Allow students to focus their time on the material they have not yet mastered, particularly given that many students have seen much of course material previously
- Increase student retention of material
- Increase student ability to apply algebraic manipulation skills in calculus problems

Online Pre-Calculus Course Elements

- Video Unit Introductions
- Video Mini-Lectures
- Course Assignments
  - Adaptive
  - Mastery-based
- Online Office Hours
  - Interactive whiteboard with VOIP
- Online Exam Proctoring
  - ID verification and proctoring



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Pre-Calculus F2F vs. Online

- Grades and Final Exams in Pre-Calculus
  - Too many confounding factors to analyze grades effectively
  - Final exam performance on paired problems shows **no discernable difference** between online and F2F
- Time spent on problem solving
  - F2F students reported spending **6 hrs/wk** on course work
  - Online students spent on average **11 hrs/wk** in ALEKS
- Instructor/Course Evaluations
  - Online students much **less happy** with course, but this is improving
- Common Final Exam for Calculus I and Calculus II
  - Online does **2-5% better** on Calculus final than F2F students
  - In progress: Drill down on individual topics

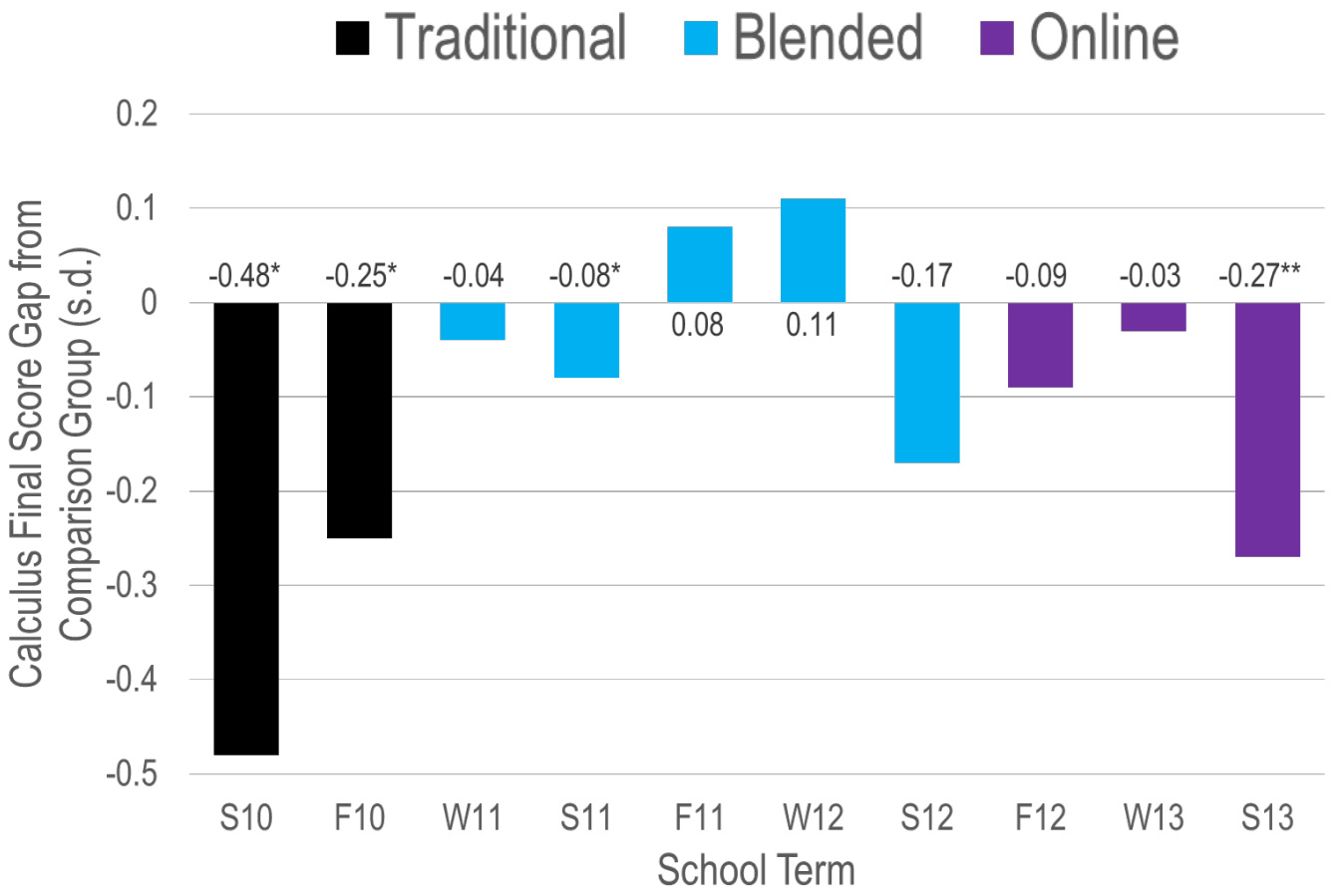
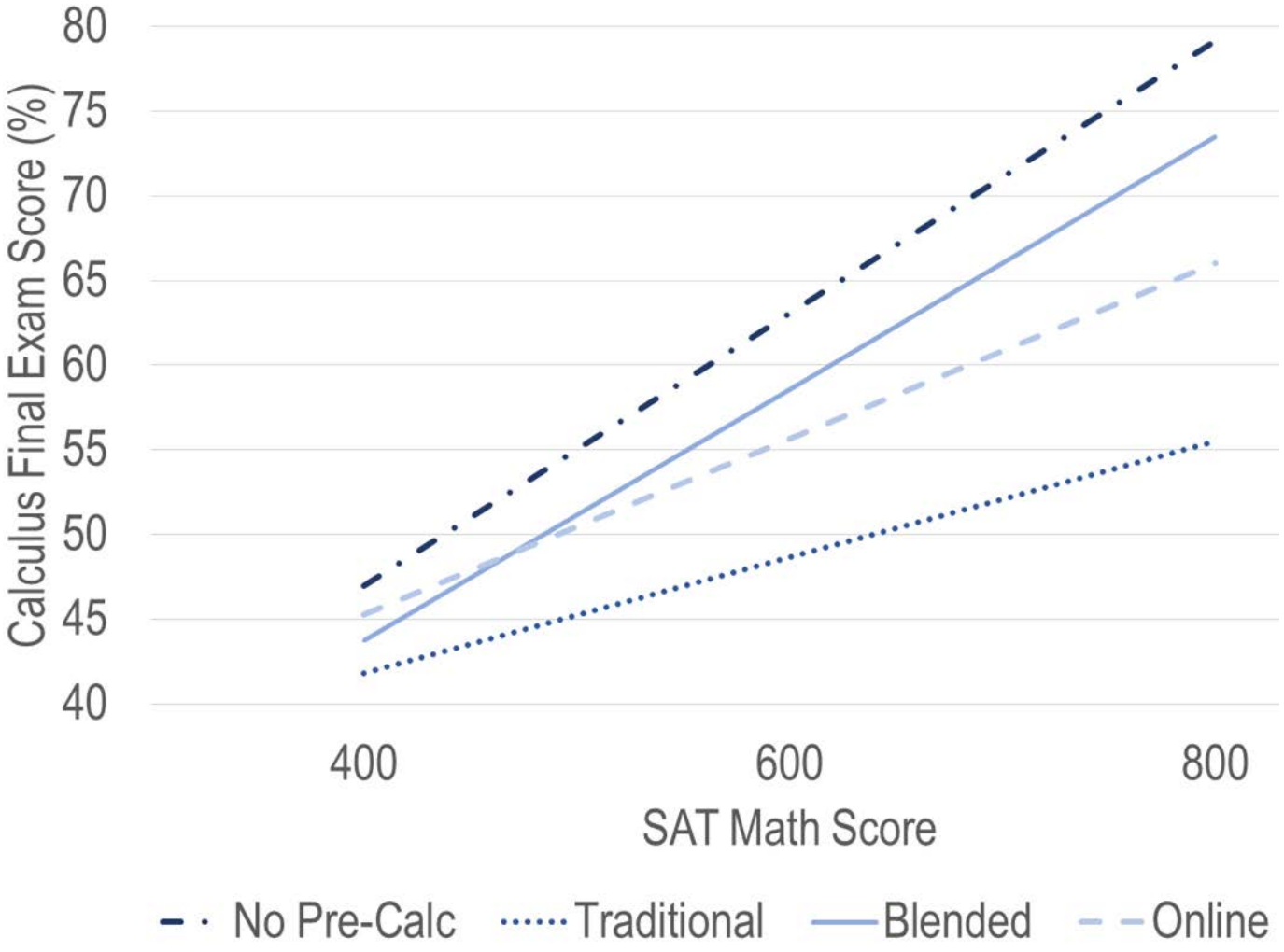


Figure. By-Term Gap Between Former UCI Pre-Calculus Students Relative to Calculus Classmates who Bypassed the Pre-Calculus Course


80
75
70
65
60
55
50
45
40
Calculus Final Exam Score (%)
400
600
800
SAT Math Score
No Pre-Calc
Traditional
Blended
Online

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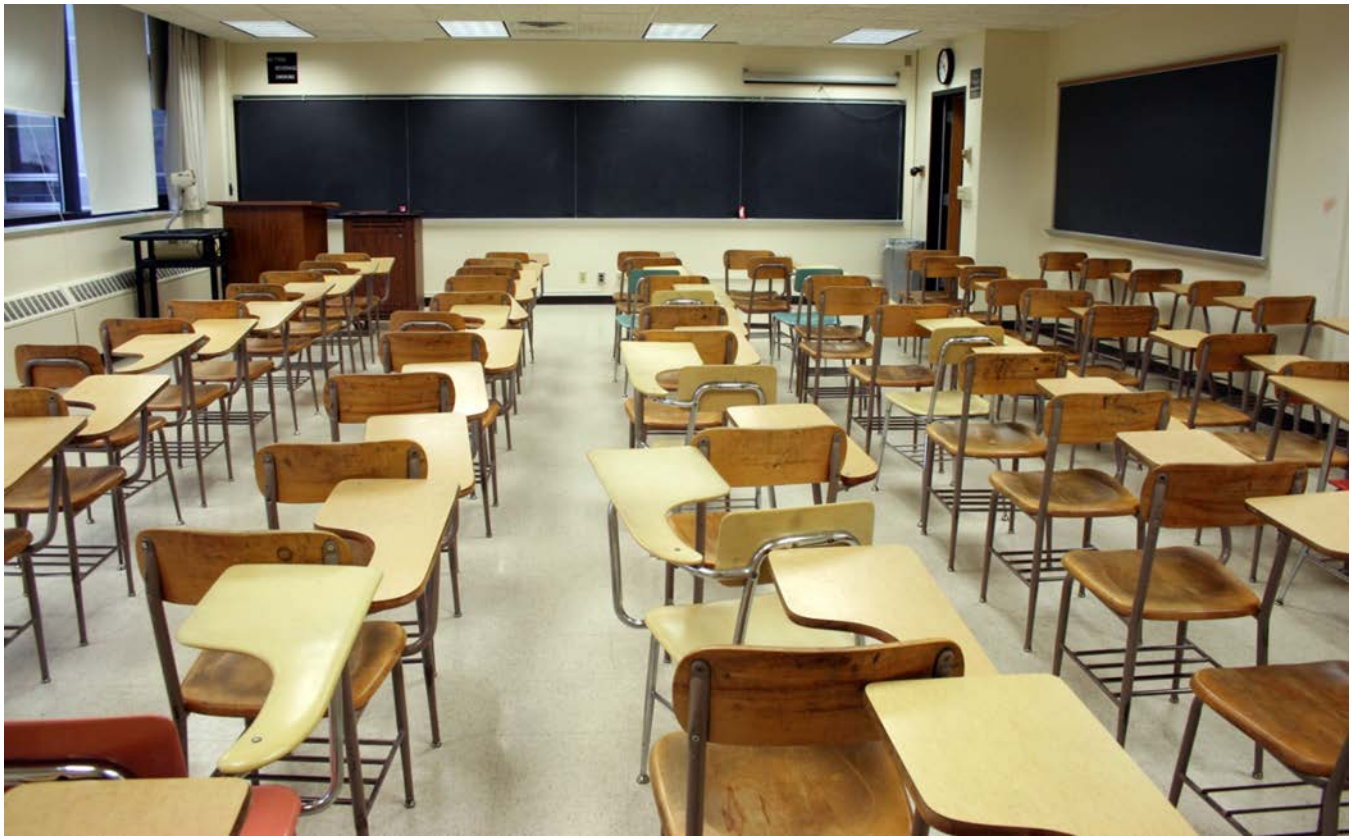
Online Pre-Calculus Revised

- Added synchronous weekly group problem solving sessions with open ended application problems
- Added “concept” videos and quizzes
- Increased interactivity in online office hours

3. Flipping the Classroom



Motivation for Flipped Teaching

- Actively engage students with mathematical problem solving
- Provide more feedback to students on problem solving approach and notation
- Foster conceptual understanding of mathematical topics
- Improve attendance
- Improve attitude

- Lecture
- Homework

- Solve problems
- Work with classmates
- Discuss concepts
- Engage in short “lectures”

- Watch video lecture
- Take notes
- Complete short questions
- Read the book

Calculus I Flipped Course

- **Before class...**
  - Watch video lecture (from Univ. of Houston and Khan Academy)
  - Take notes on a partially filled out form
  - Complete 1-3 “You Try It” problems
  - Read a section of textbook
- **During class…**
  - Compare “You Try It” problem solutions with group
  - Solve 5-10 assigned problems with group
  - Discuss common issues as a class
  - Concept questions polls
  - Random notes check for 1% of grade

- Benefits of video lecture:

Replayable

Can adjust speed

Perfectable

Can watch anytime

Rewindable
& Pausable

Can incorporate multimedia assets

Scalable

Captionable

Efficient

Math Flipped Teaching Trials

- 1 Calculus I, 4 Calculus II and 1 Combinatorics class taught “flipped”
- In Spring 2013, the flipped Calculus I class outperformed the other (smaller) sections on the common final exam.

* With the exception of one very small section comprised mostly of international students.

- Markedly improved attendance
- Mostly positive responses from students in evaluations

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4. Best Practices

Course Sample Set

Online:

- Pre-Calculus – *Eichhorn, Lehman*
- Combinatorics – *Lu, Eichhorn*
- Statistics - *Baldi*
- Pre-Chemistry – *Potma*
- Intro to Astronomy – *Smecker-Hane*
- Physics for Bio Majors I – *Dennin*
- Physics GEs – *Dennin, Collins*
- Biology I – *O'Dowd, Williams*
- Biology II – *Loudon*
- Dynamics – *Jabbari*
- Molecular Pharmacology – *Jafari*

Flipped:

- Calculus I – *Eichhorn*
- Calculus I, II – *Lehman*
- Combinatorics – *Eichhorn*
- Biology I – *Williams*
- General Chemistry Lab – *Link*
- Computer Aided Design - *Dimas*

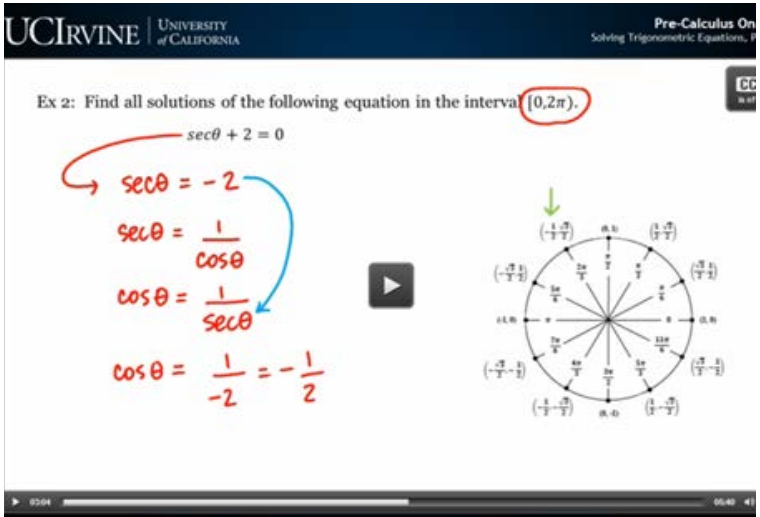
Online Facilitation

- Require some sort of engagement with instructor or peers
- Use synchronous online office hours
- Promote discussion forum usage
- Provide meaningful feedback somewhere in course
- Give explicit instructions for communication
- Give explicit instructions for expectations of students
- Send motivational emails

Producing your own videos

Creation Mechanisms

- Voiceover PPT
- Tablet written
- Webcam
- Cellphone / video camera

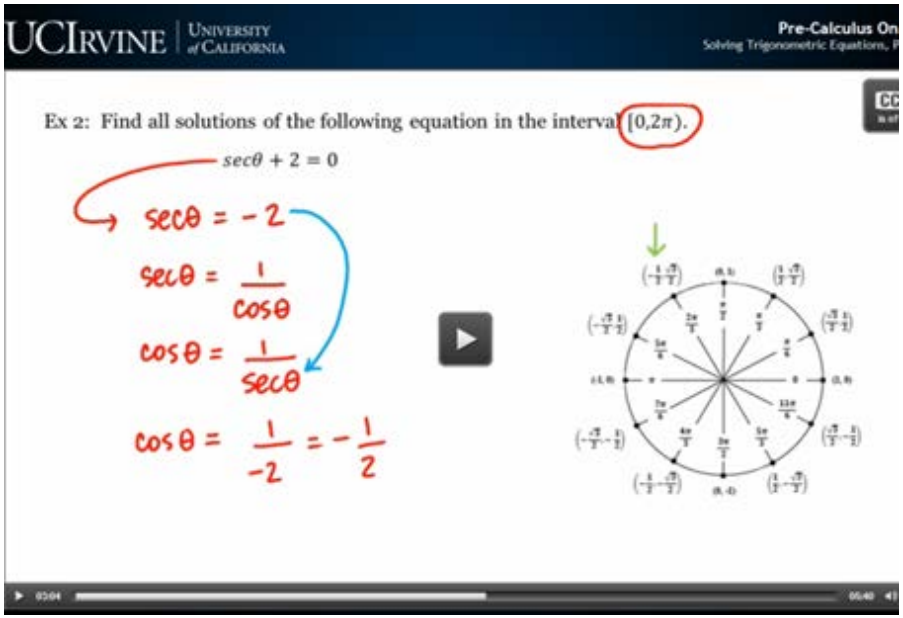


Tech Equipment

- Quality microphone
- Camtasia studio
- Doceri (iPad)
- iMovie (Mac)
- Zaption (*free!*)
- Tablet
- Wacom digitizer stylus
- Hosting platform

Video Tips

- “Chunk” into short segments
  - Definitely less than 15 minutes
  - Preferably less than 8 minutes
- Make reusable
  - Avoid numbering
  - Strive for timelessness
  - Flexible textbook alignment
- Strive for engagement
  - Avoid reading a script verbatim
  - Take advantage of the format
- Be aware of copyright
- Consider accessibility



Online Assessment

- Give very frequent assessments
- Use variety of mechanisms
- Use in-video quizzes for self-assessment
- Give feedback on forums (if graded) early
- Consider academic integrity
- Use pre-course logistics quiz
- Consider interleaving problems
- Plan to calibrate with F2F assessments

Flipped In-Class Activities

- Guided
- Scaffolded
- Homework replacement
- Peer interactive
- Expert assistance
- Individualized help
- Motivated
- Incorporate study skills

- Problem solving oriented
- Concept oriented
- Solutions available

Flipped In-Class Activity Tips

- Explicitly explain benefits of class structure
- Have students use pre-class notes
- Assign groups
- Use handouts sometimes
- Use less handouts than students
- Incentivize completion
- Actively facilitate
- Bring common questions to full class discussion
- Mix it up!

5. Simple Innovation Starting Points

8 Easy Ways to Try Technology Innovation in Teaching

1. Conduct exam prep session synchronously online
2. Review exam solutions via video lecture
3. Provide OER remediation assets at beginning of course
4. Create your own pre-class remedial review video
5. Flip a single class session or unit
6. Use video assets from another source to flip a course
7. Use publisher online homework system in creative ways
8. Use OER materials for in-class activities

Something to think about…

How could or should our standard educational model change in response to widespread access to education enabling technologies?

- Thank you!