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Online and Blended Learning: How the New Approaches to Learning Work in the World of STEM

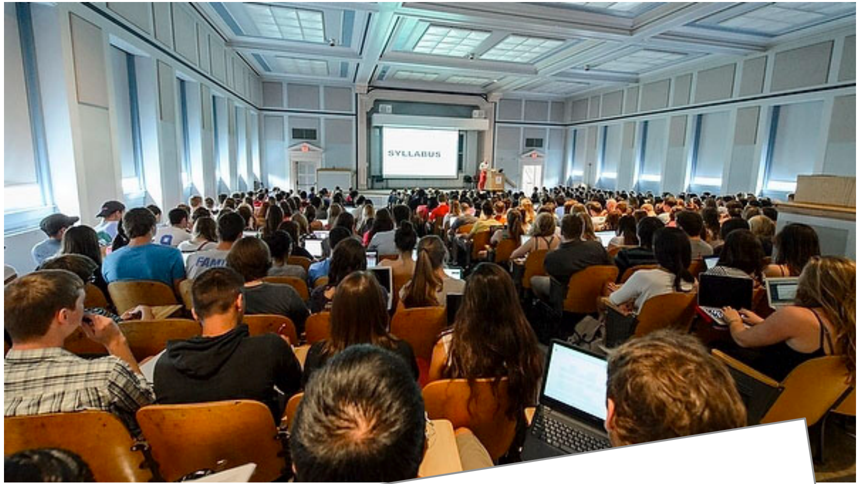
James Caras & Mats Selen

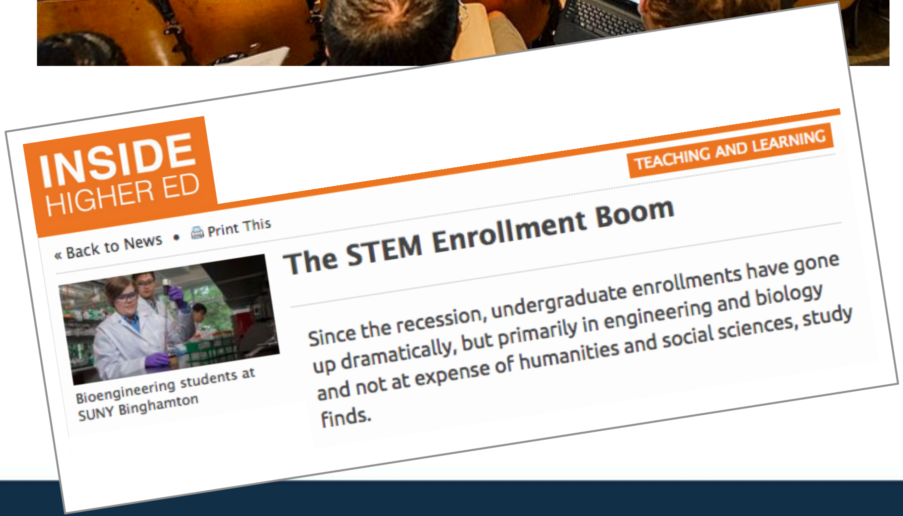
Trends

Problems to solve:

- Cost savings needed
- STEM enrollment increase

Result: Shift towards larger classrooms in foundational STEM courses





INSIDE HIGHER ED

TEACHING AND LEARNING

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The STEM Enrollment Boom

Since the recession, undergraduate enrollments have gone up dramatically, but primarily in engineering and biology and not at expense of humanities and social sciences, study finds.

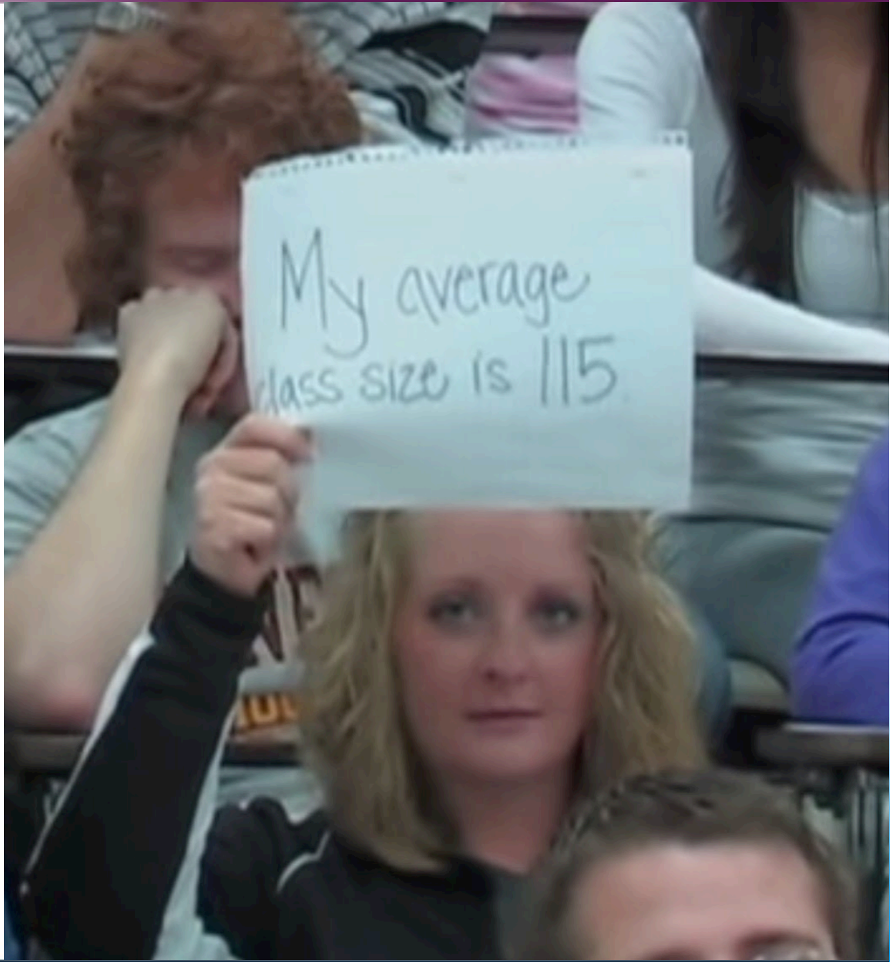
Bioengineering students at SUNY Binghamton

Size Matters: Large Class Impact

- Decreased student engagement
- Decreased outcomes
- Decreased student satisfaction / course evaluations

Lower Engagement in Large Classes

- Lower attendance
- Lower classmate interaction and support
- Lower student preparedness for class
- Lower class participation



Innovations in Education and Teaching International Volume 53, Issue 3, 2016

Attendance and Outcomes

- Class size matters: Smaller the class, the less absenteeism
- More absenteeism in foundational courses
- Students with strong attendance achieve one letter grade higher performance
- *How do we get students to go to large foundational classes?*

"Do Students Go to Class? Should They?" David Romer. J. of Econ. Perspectives,, Summer, 1993, pp. 167-174

Class Size and Outcomes

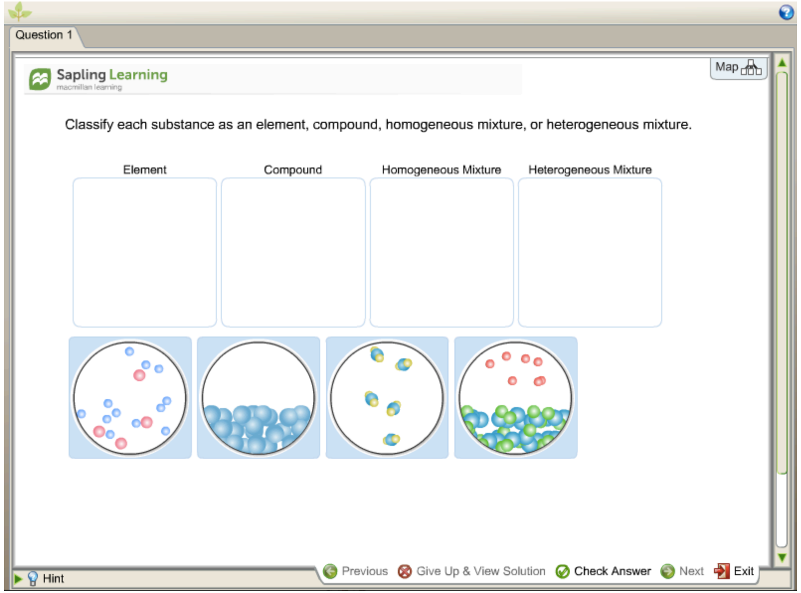
- Recent studies analyzing class size and outcomes in higher education indicate larger class sizes have:
  - Little to no impact on fact retention
  - Negative impact on attainment of **higher-order thinking skills**:
    - Problem-solving
    - Written and collaborative expression
    - Critical thinking

  Problem for STEM?

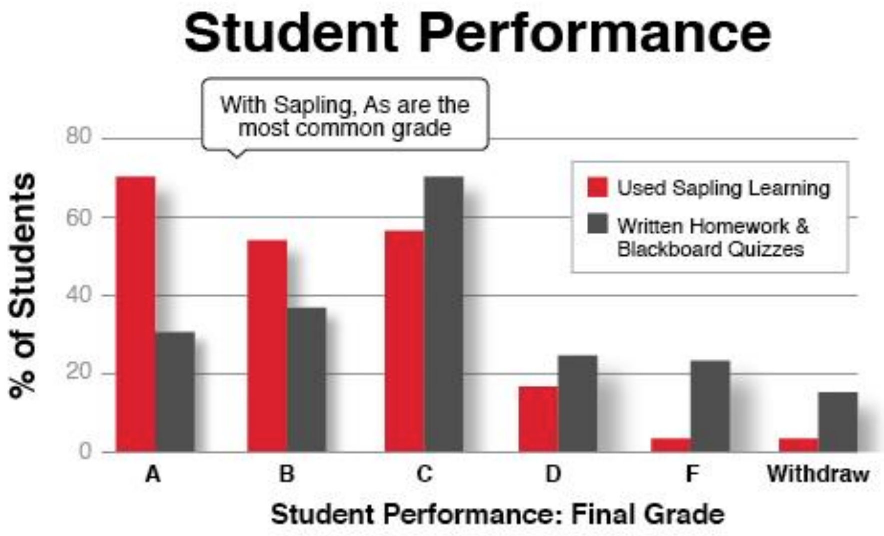
- Why? *Deep engagement required*

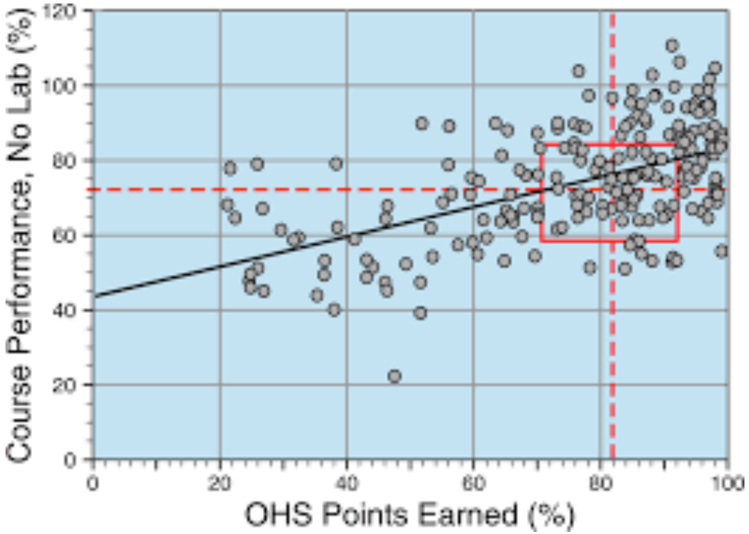
Outside Class Problem-Solving

- **Problem to solve**: shift from hand-graded homework to ungraded "suggested problem sets" *which students don't do*
- **Solution**: Hybrid course with online homework component
  - Automatically graded
  - Built in feedback, instruction, and tutoring



Online Homework Outcomes





- ➢ Numerous studies show ~1 letter grade improvement returning to graded online homework

Liberatore. *J. Chem. Eng. Education* 2013
Parker and Loudon. *J. Chem. Ed.* 2014

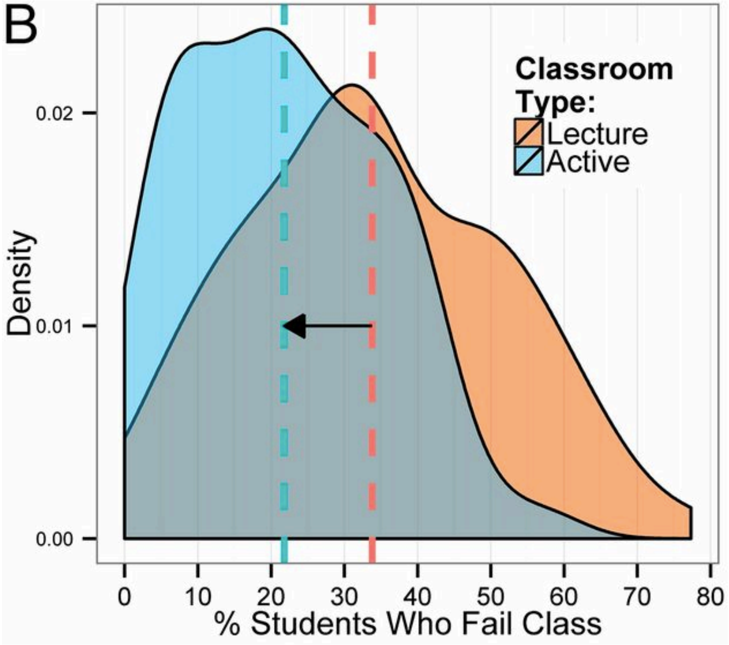
Valuable Class Time: Enable Active Learning

Problems to solve:

- Class attendance most valuable to student success: *how do we make better use of classroom time*?
- Students walking into lectures with little exposure to covered topics makes active learning difficult – *how do we free up class time?*

Solutions:

- Pre-lecture and pre-lab activities
- Active in-class engagement with student response system



Freeman. Active learning increases student performance in science, engineering, and mathematics. PNAS 111, v23.

Active learning increases student performance in science, engineering, and mathematics

Scott Freeman[a,1], Sarah L. Eddy[a], Miles McDonough[a], Michelle K. Smith[b], Nnadozie Okoroafor[a], Hannah Jordt[a], and Mary Pat Wenderoth[a]

[a]Department of Biology, University of Washington, Seattle, WA 98195; and [b]School of Biology and Ecology, University of Maine, Orono, ME 04469

Edited* by Bruce Alberts, University of California, San Francisco, CA, and approved April 15, 2014 (received for review October 8, 2013)

. . .

of controls over student quality and instructor identity. This is the largest and most comprehensive metaanalysis of undergraduate STEM education published to date. The results raise questions about the continued use of traditional lecturing as a control in research studies, and support active learning as the preferred, empirically validated teaching practice in regular classrooms.

Feedback, Data, and Analytics

- Key benefit of online learning platforms is *creating a complete picture of learning* with analytics
- Enabling learning science: data driven instruction and course design
- Challenge is:
  - Actionable data for the student and instructor
  - Supporting learning outcomes as defined by the institution

360° Focus on Hybrid

- Required:
  - Tools: hardware, software
  - **Training: Dedication to faculty Professional Development**

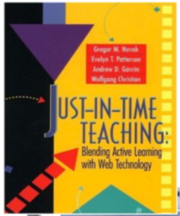
Example: Intro Physics at Illinois

Mechanics (calc) :1254
Electricity & Magnetism (calc) : 831
Thermo & Stat. Mech. (calc) : 692
Quantum Physics (calc) : 687
Mechanics & Heat (alg) : 331
E&M and Modern (alg) : 358

Big. Complex. Many moving parts.

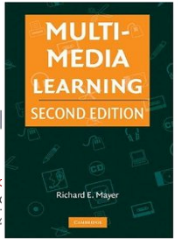
Great platform for education research

“Flip” to optimize class-time



FlipItPhysics
macmillan learning

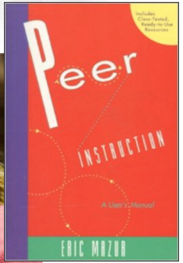
Just in Time Teaching



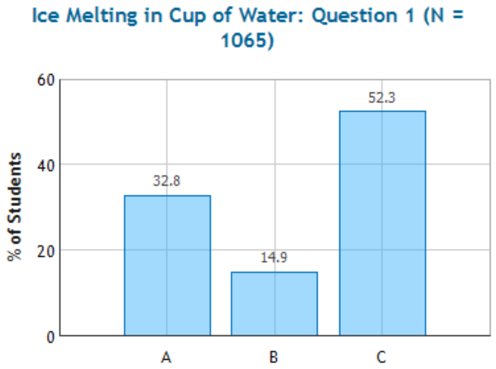
Pre Lectures

iclicker

Peer Instruction



Just in Time Teaching Example



An ice cube is floating in a glass filled with water. When the ice melts, the level of the water will:

A) Go up, causing water to spill out of the glass
B) Go down
C) Stay unchanged

Student explanations for "it spills over"…

	water in ice must add somewhere to water in glass
ail	The water level will rise. I learned that from Al Gore in "An Inconvenient Truth"
email	since the ice completely melts the volume of ice not in the water will exceed the volume of the glass and surface tension will unlikely hold the excess in place
	dope
ail	because the ice floats with some of its volume above the water, when it melts it will rise the level of the water
	the melted water has a higher density as ice and will flow into the cup to cause the overflow
email	meep!
	The same percentage of the ice's volume is always above the water, which means when the ice cube gets smaller, the volume that is above gets smaller, and the extra volume makes the water spill.
ail	1
email	The density will increase.
ail	same volume but there is water floating above the cup in the form of ice
il	well the volumes gotta go somewhere am I right???

Lecture Slide:

An ice cube is floating in a glass filled with water. When the ice melts, the level of the water will:

A) Go up, causing water to spill out of the glass

The water level will rise. I learned that from Al Gore in "An Inconvenient Truth"

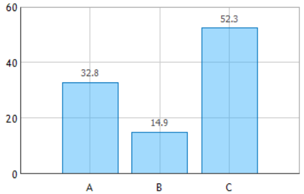
B) Go down

Volume of ice is greater than volume of water

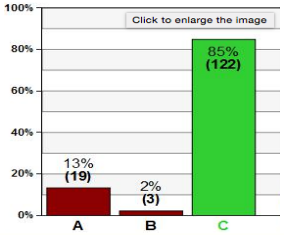
C) Stay unchanged

The melted water has exactly the same mass as the ice cube

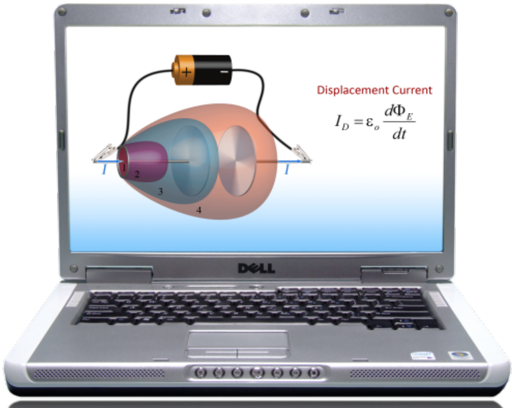
Before Class

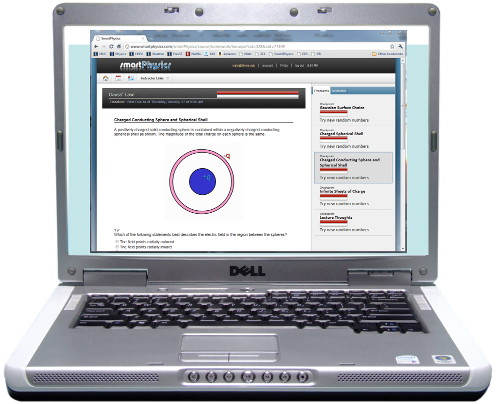


During Class



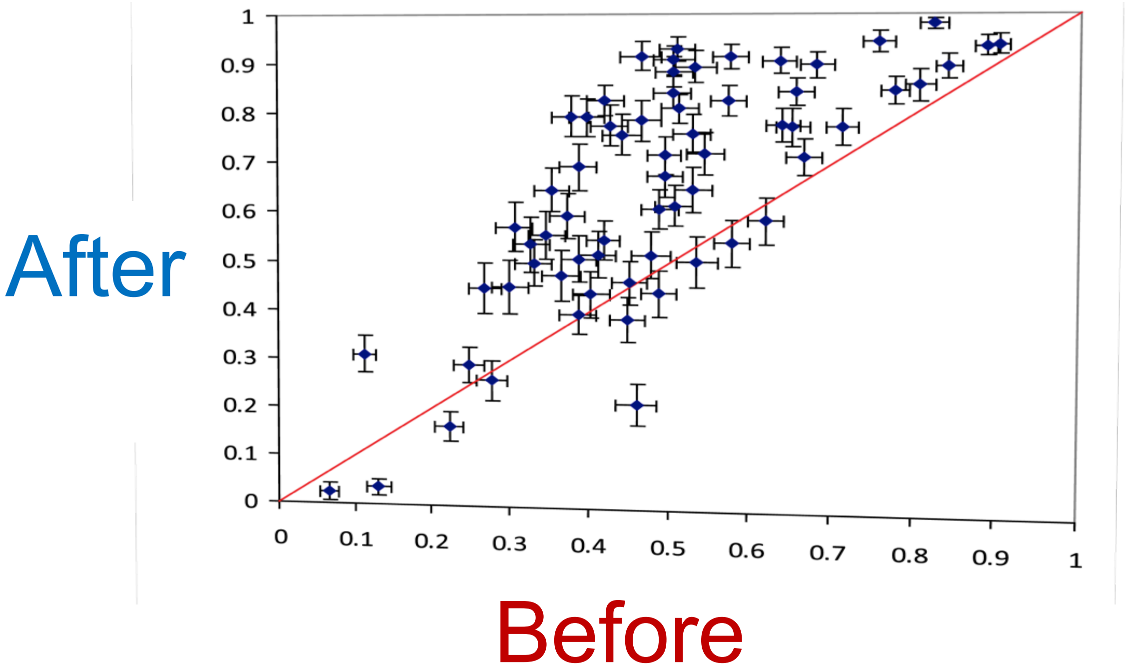
How does this approach impact our students?



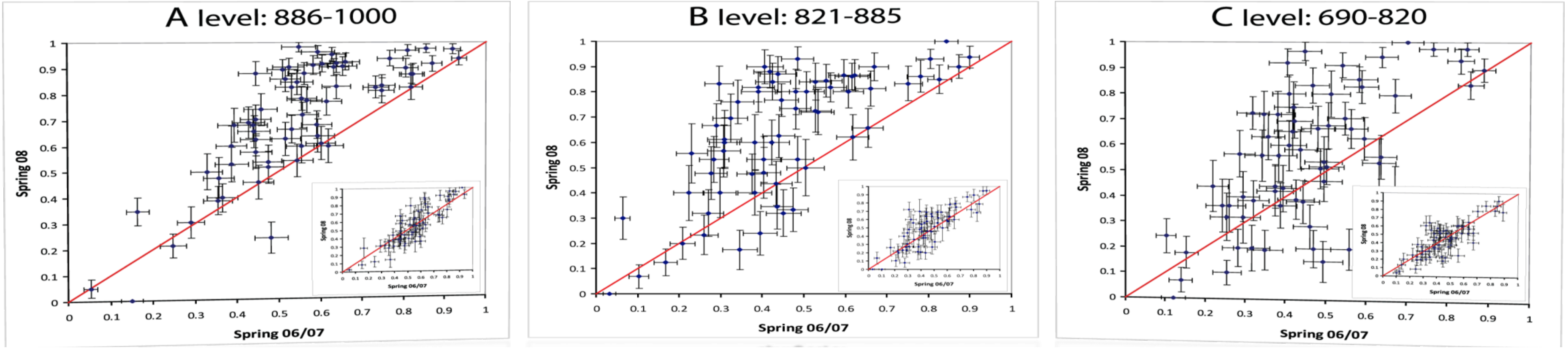


Am. J. Phys. 78, 755-759, 2010
Phys. Rev. ST Phys. Educ. Res. 6, 1-5, 2010

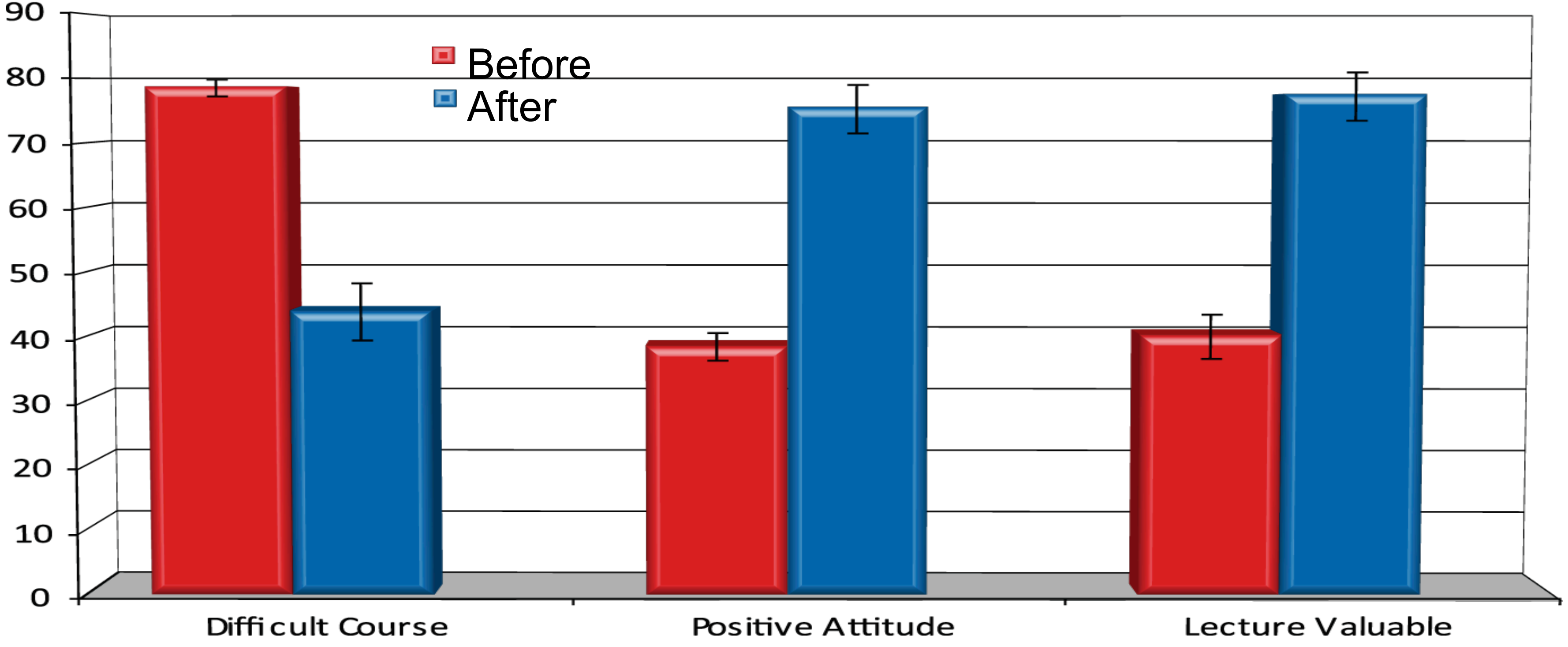
Understanding of E&M Concepts



Improvement seen for all students



Student Perception of the Course



Lab Reforms:

Encourage critical thinking & creativity

Why are we doing this now ?

Research

Measuring the impact of an instructional laboratory on the learning of introductory physics

American Journal of Physics **83**, 972 (2015);

Carl Wieman
Department of Physics, Stanford University, Stanford, California 94305 and Graduate School of Education, Stanford University, Stanford, California 94305

N. G. Holmes
Department of Physics, Stanford University, Stanford, California 94305

(Received 27 February 2015; accepted 9 September 2015)

> The average benefit on lab-related questions for students who took the lab, in both courses, was within 0.6% of the score of students who did not, …

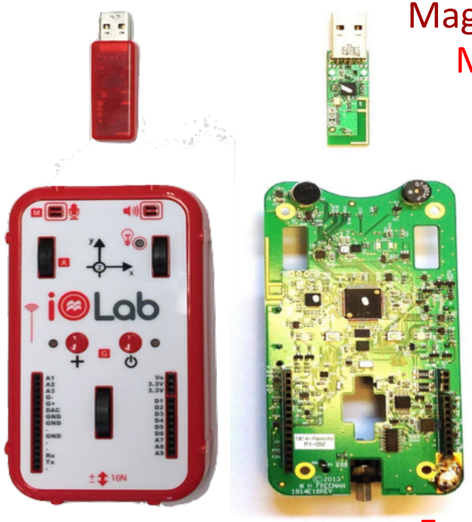
Design and Reflection Help Students Develop Scientific Abilities: Learning in Introductory Physics Laboratories

Eugenia Etkina et. al. The Journal of the Learning Sciences, 19: 54–98, (2010)

> Students benefit more from activities that stress creativity, communication, and sense-making.

Collaborators

www.IOLab.science



Magnetometer
Microphone
Buzzer
Light Intensity
Accelerometer
Gyroscope
Temperature
Pressure
Coded wheel
Force Probe
Expansion Headers

Our New Approach:

Katie Ansell

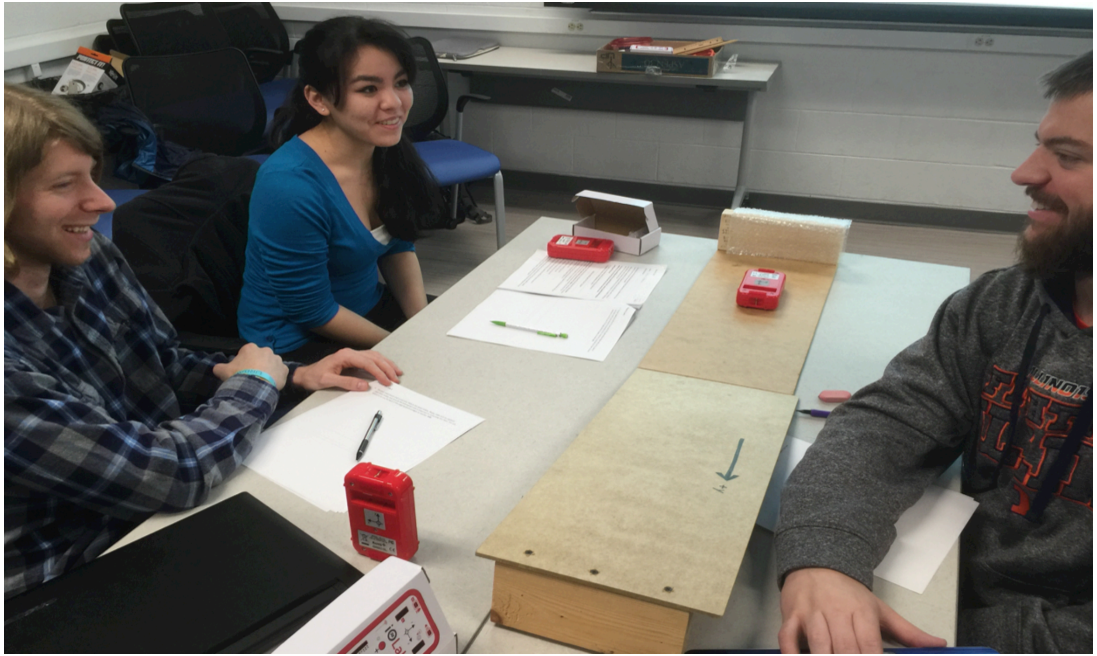
Each student has their own (powerful, simple) lab system

Tools

Students explore individual lab activities at home, followed up by group activities in class

Time

Students answer questions and share data online

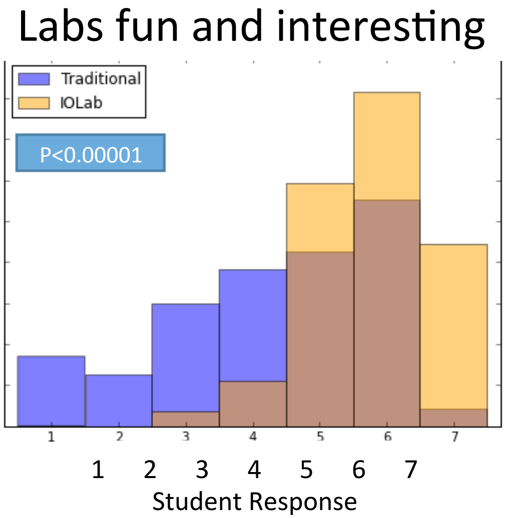


Students are challenged to:

- design experiments
- make sense of data
- work together
- work harder
- work longer

Students like new approach…

"I'm used to the dry cut, fill in the blanks crap that I was subjected to in high school. This physics labs challenges me to think for myself and be curious. I really appreciate that."



Students want to be challenged !

Summary

- What is most important for learning ?
  - Student engagement with topic
  - Student engagement with instructor during precious class-time
- What are the challenges to delivering this ?
  - High enrolment (must be scalable)
  - Limited budgets (both students and institutions)
  - Not all technology is pedagogically good (i.e. distraction)
  - *Faculty confidence, buy-in, and training*
- What are the opportunities are available to help ?
  - Scalable technology validated by discipline based education research