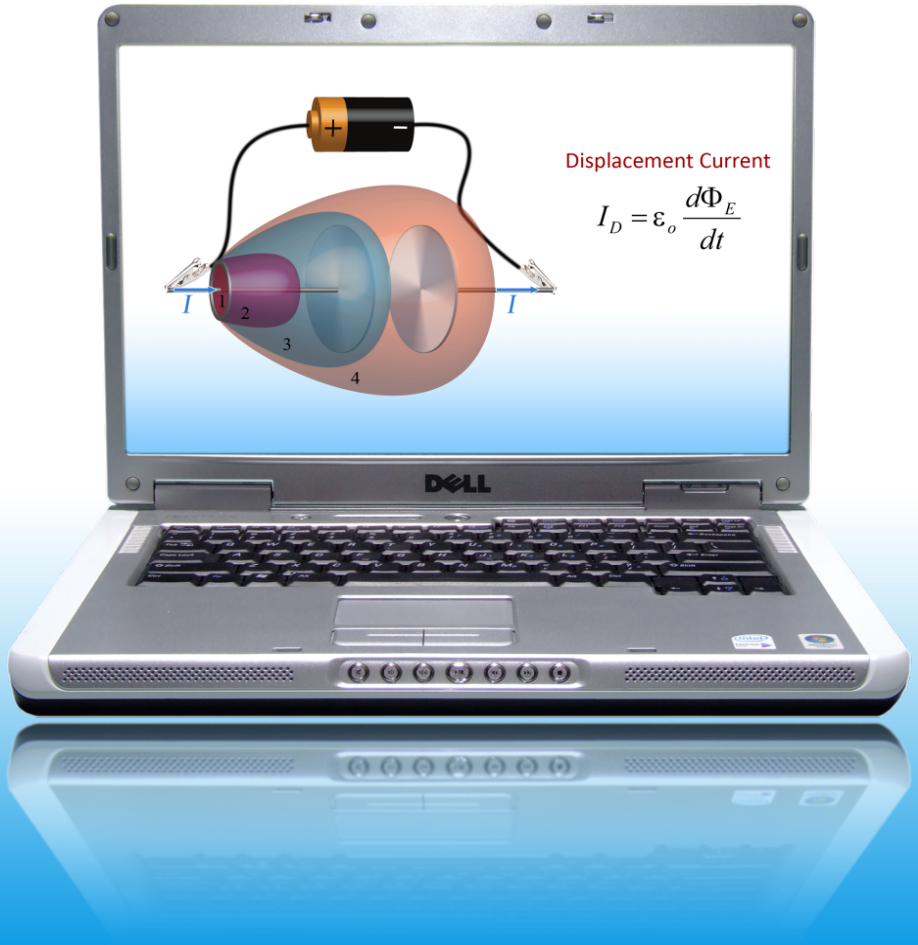
# Flipping Intro Physics at the University of Illinois




Mats Selen
UIUC Physics

# Talk Outline

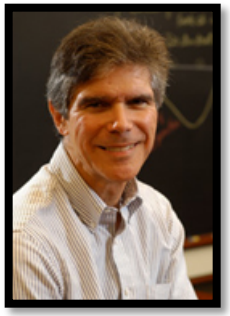
- Initial Illinois course revisions (1996-2001) (5 min)
  - Why everyone should *just do this*.
- Two cool projects enabled by this
  - Flipping the classroom (2008 - ...) (20 min)
  - Interactive Online Labs (brand new)
- Fantastic Questions (5 min)

Physics Education Research

# Colleagues

Faculty:


Gary Gladding


Jose Mestre


Mats Selen


Tim Stelzer

Grad Students & Post Doc:


Katie Crimmins


Witat Fakcharoenphol


Brianne Gutmann


Sara Rose


Noah Schroeder


Zhongzhou Chen

AP & Affiliates:


Morten Lundsgaard


Michael Scott


Michel Herquet


Vincent Boucher


Geoffroy Piroux


Abe Kocheril

# Intro Physics at Illinois

## Enrollment
(last semester)

PHYS 101: 409
PHYS 102: 395
PHYS 211: 1210
PHYS 212: 885
PHYS 213: 774
PHYS 214: 781

# Calculus Based

Physics 211 (4 hrs, mechanics)

Physics 212 (4 hrs, E&M)

Physics 213/214 (2+2 hrs, SM, QM)

Over 4000 students/year in these 2 classes

Mostly Engineering & Physics majors

Traditional Class Structure:
Lecture, Lab, Discussion…

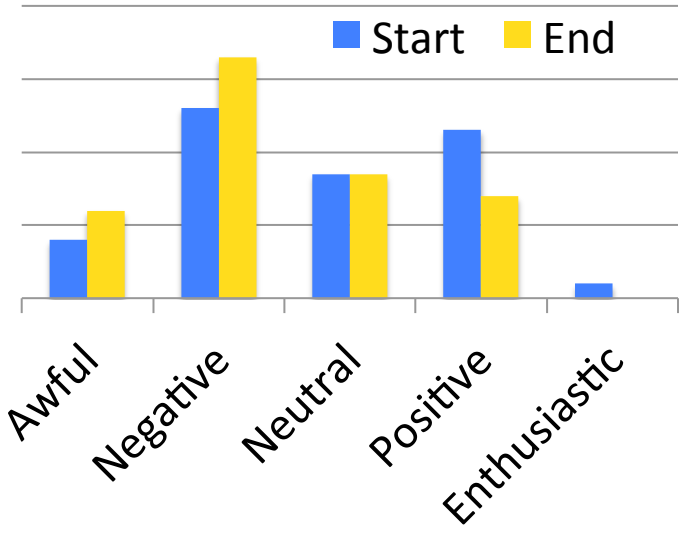
# How we changed things ~ 1996:

- Team teaching: 3-4 faculty share the load:
  - Lecturer(s), Discussion Director, Lab Director
- Permanent Infrastructure
  - Significant administrative support from department
  - Course material is basically fixed; changes are incremental
- This lowers the bar for participation.
  - Normal teaching load; faculty have time to do other things.
  - Enables innovation
- Pain & Gain are shared
  - No burnout & No heroes; consistent high quality.
  - Sustainable.

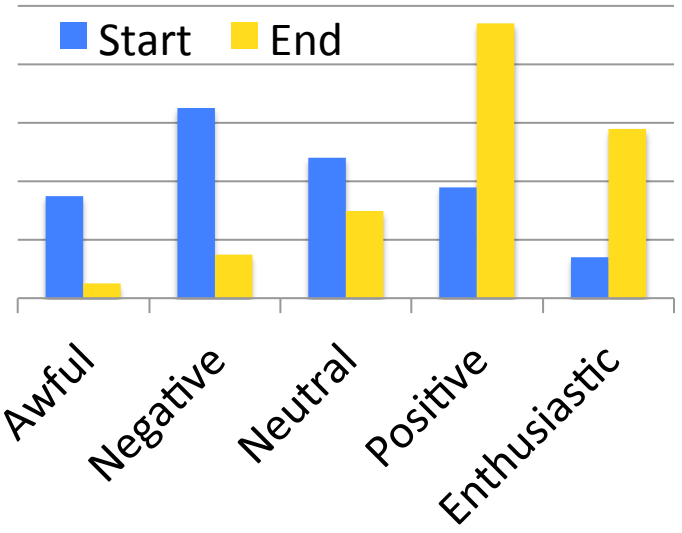
If this didn't happen I wouldn't have anything else to talk about today.

# Effect of initial renovation:

Before (1995)




After (2001)




Before (Spring 95)
Total Physics TAs = 77
# "Excellent" = 15
19 ± 5 %

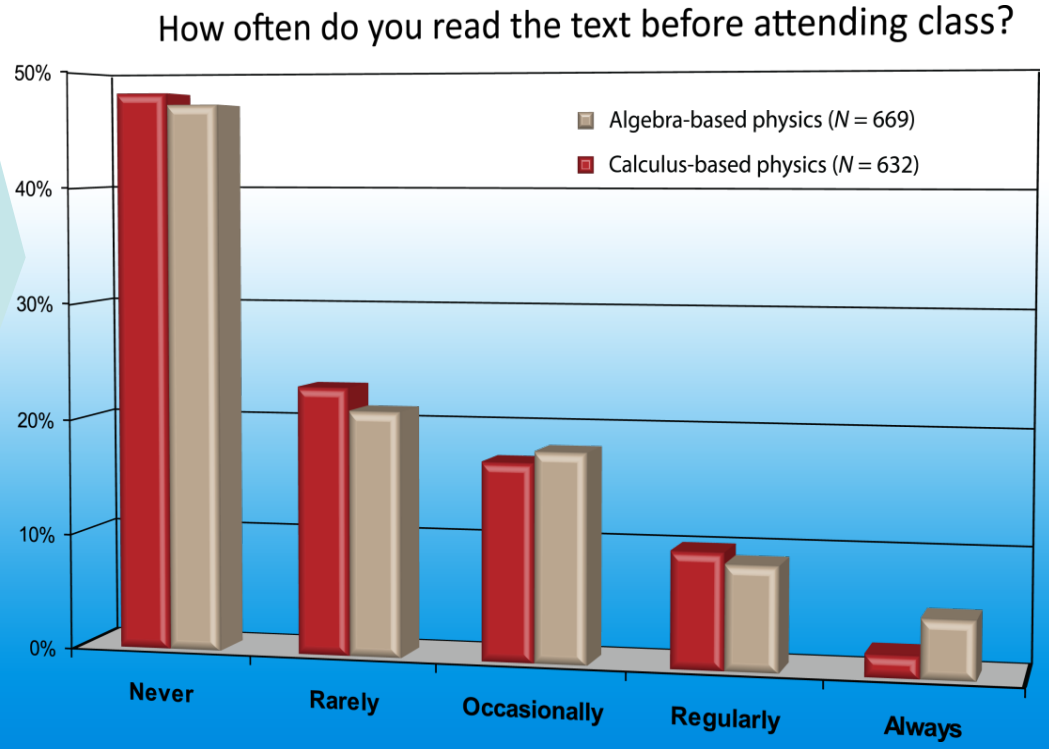
After (Spring 01)
Total Physics TAs = 75
# "Excellent" = 58
77 ± 6 %

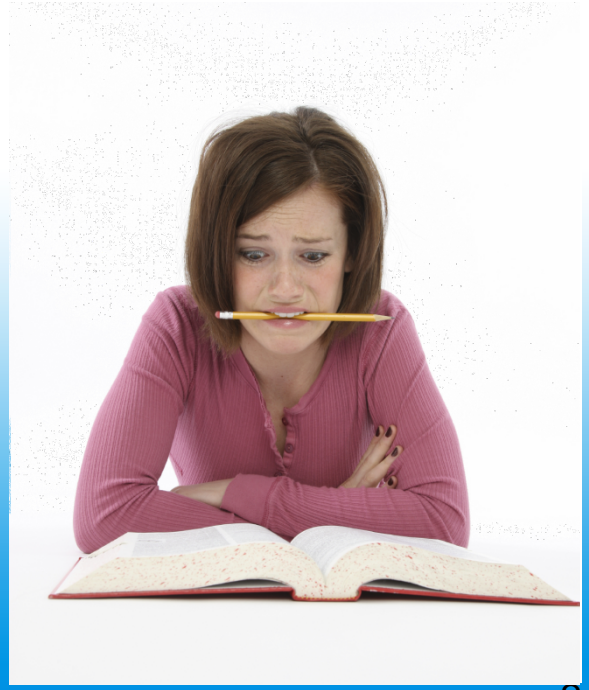
Incentive for further improvement: Flip

# Why flip the classroom ?

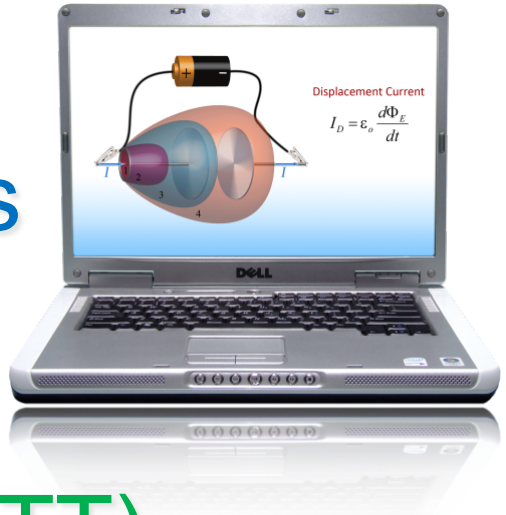
Students are not reading the text and aren't prepared for class

- Lecturer has to assume that students know nothing coming into the classroom.
- We spend (waste) a lot of time going over very basic material.
- Difficult material is often rushed and student only see it once.



# New Approach to Lecture (2008 - ...)



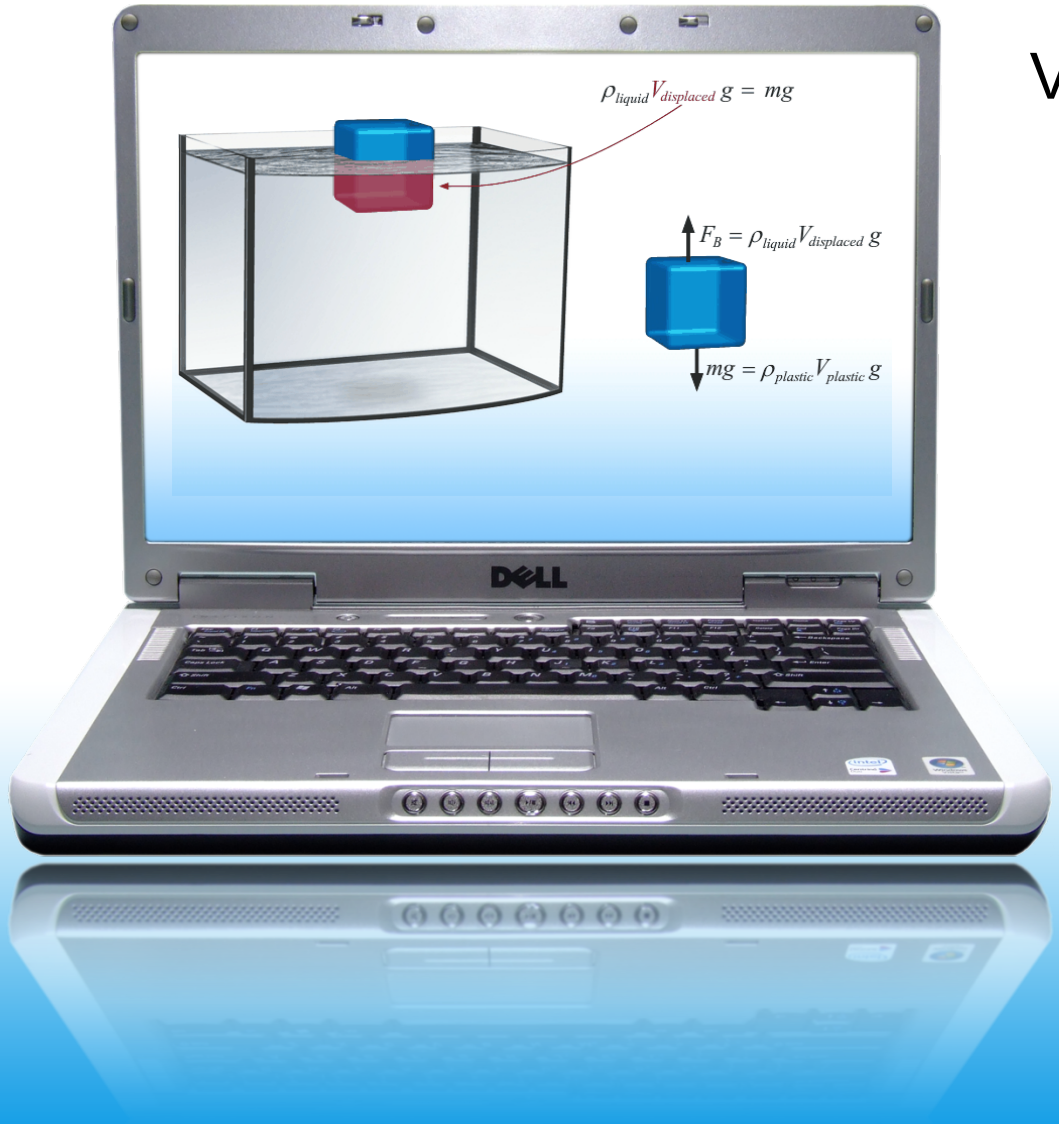

Pre Lectures

Checkpoints (JiTT)

Peer Instruction

AKA Flipping the Classroom

# Pre Lectures



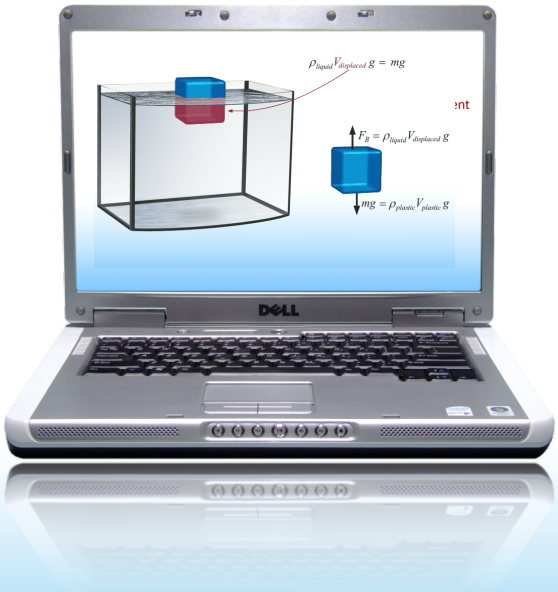

Viewed prior to each lecture (usually the night before)

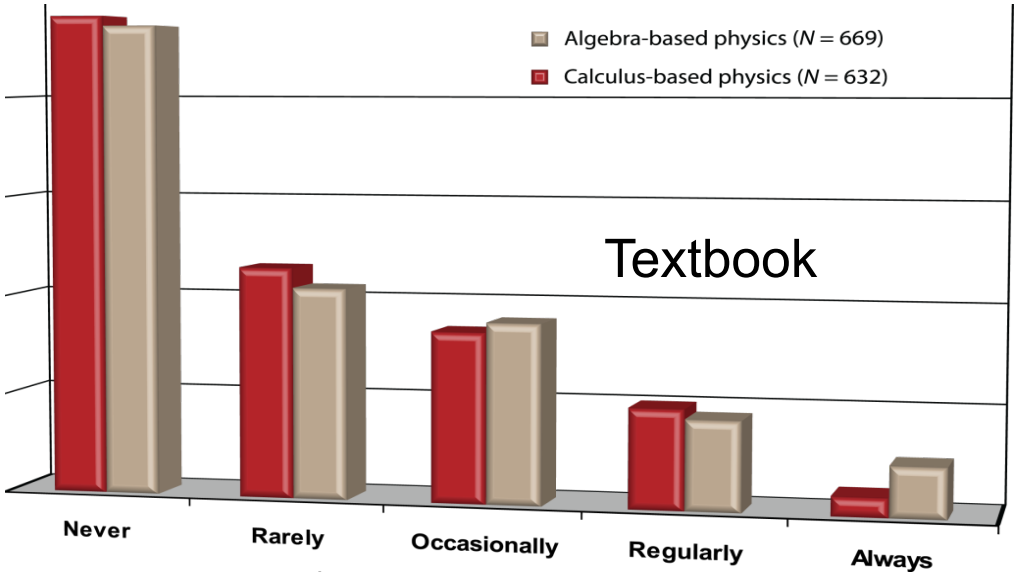
Students do this instead of reading a textbook

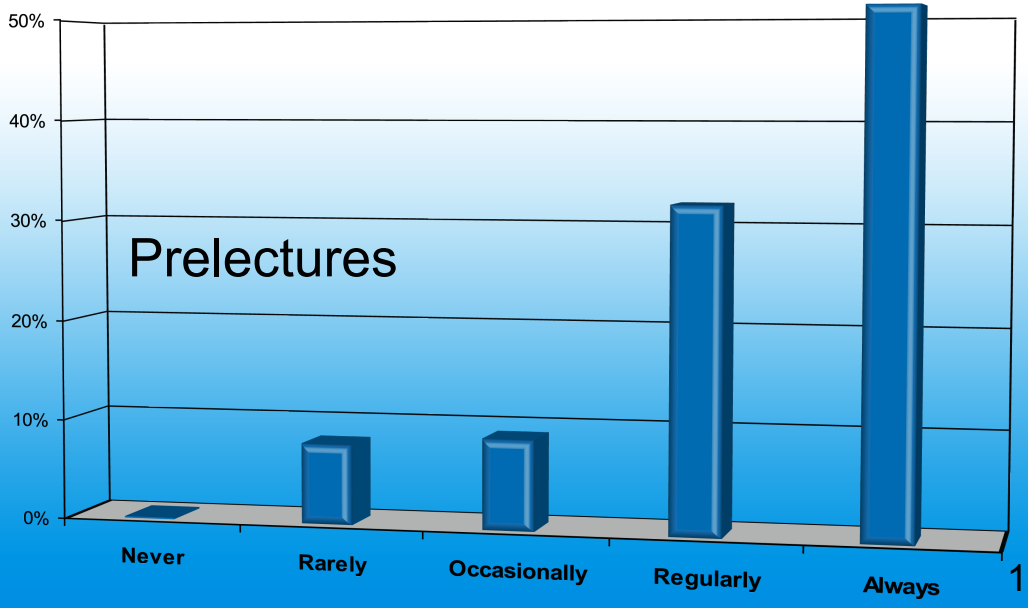
Introduces all concepts for the coming lecture and provides feedback to both students and professor

Show Example

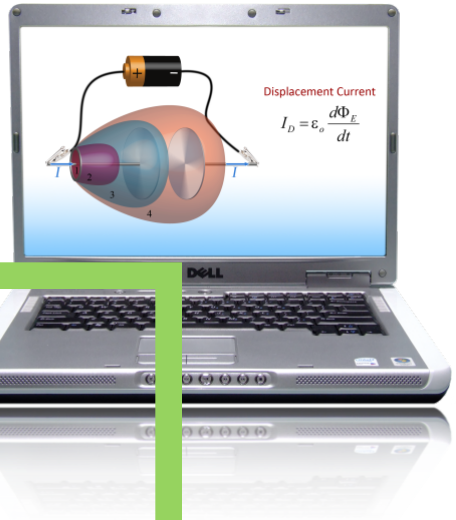
# Our students watch the prelectures

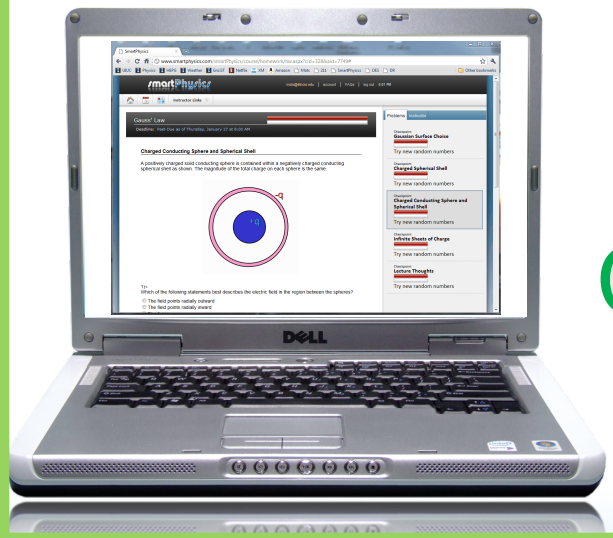


# Pre Lectures



# Checkpoints (JiTT)

# Peer Instruction

# Checkpoints

## (aka Just in Time Teaching)


Online knowledge check of prelecture concepts

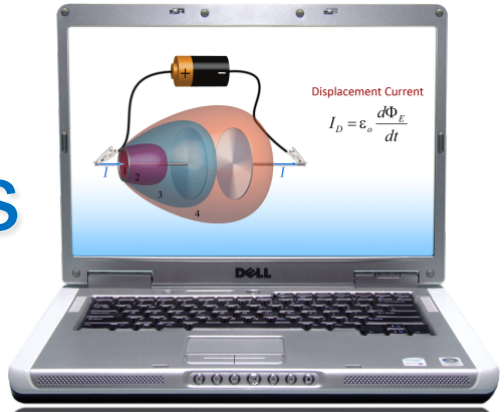
Completed after Prelecture but before Lecture.

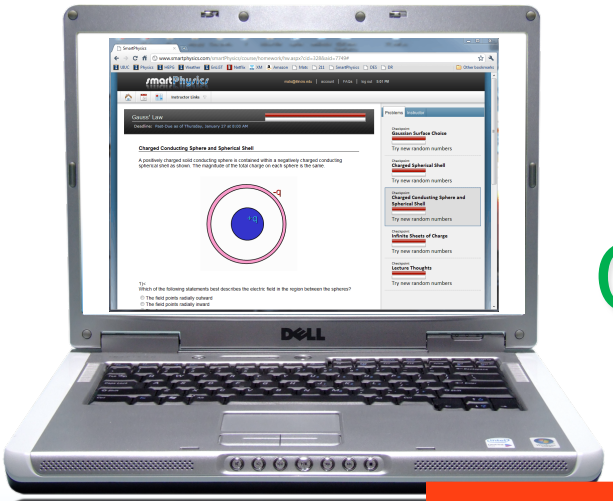
Increases student buy-in for upcoming lecture

Feedback to professor helps lecture prep.

(we've been doing this for 15 years)

# Pre Lectures



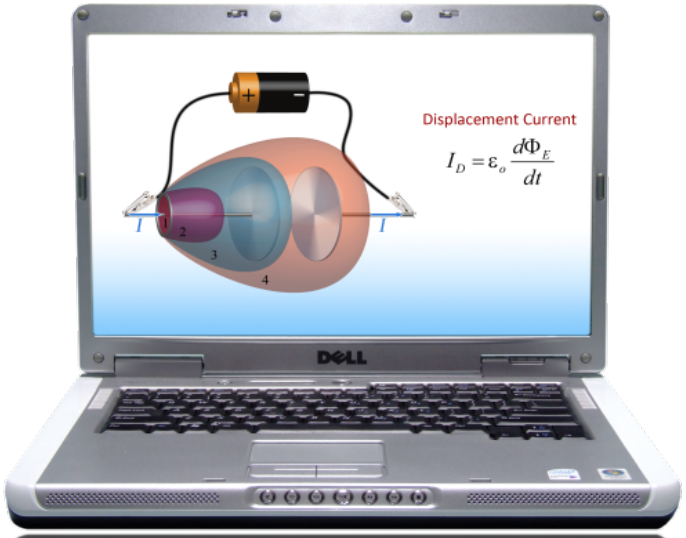

# Checkpoints (JiTT)

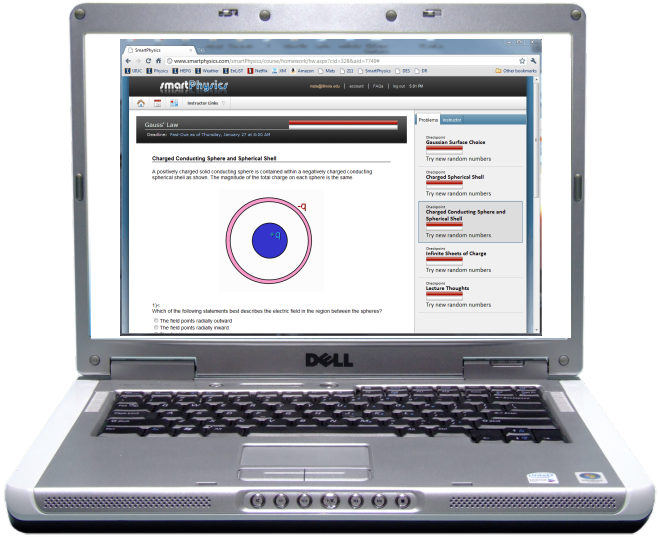
# Peer Instruction

# Lectures = Peer Instruction

- Lectures are very interactive
  - We know students are prepared (Prelectures)
  - We know their misconceptions (Checkpoints)
- Built around Prelecture concepts & JiTT feedback.
- Typically ask 6-10 clicker questions per lecture

# How does all this impact our students?

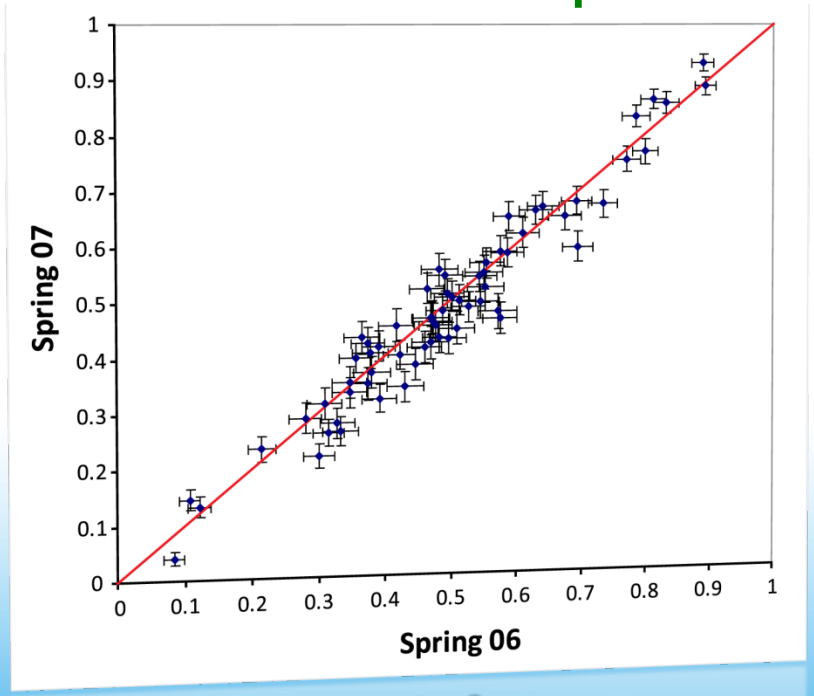


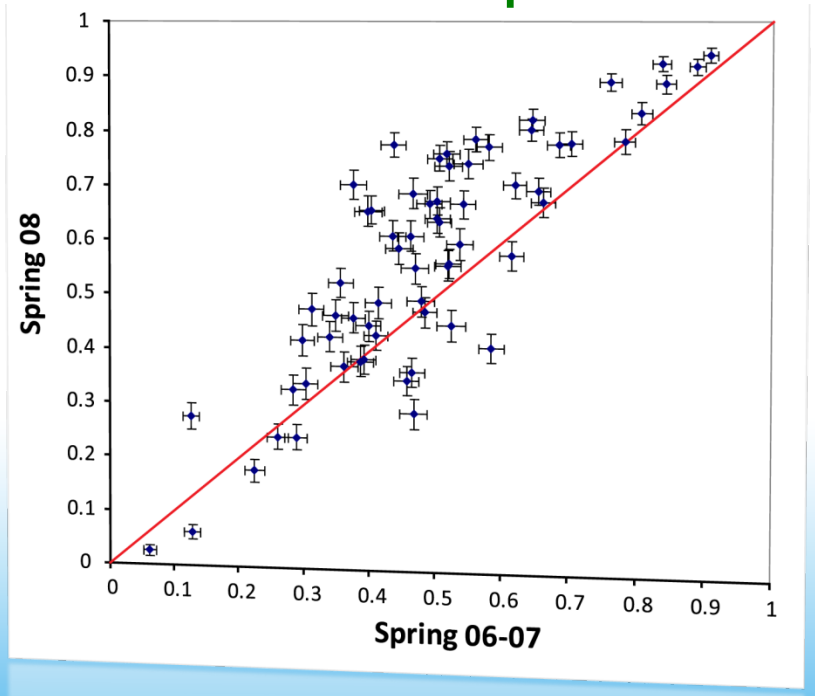

Am. J. Phys. 78, 755-759, 2010
Phys. Rev. ST Phys. Educ. Res. 6, 1-5, 2010

# Checkpoint Study
## Overall Results

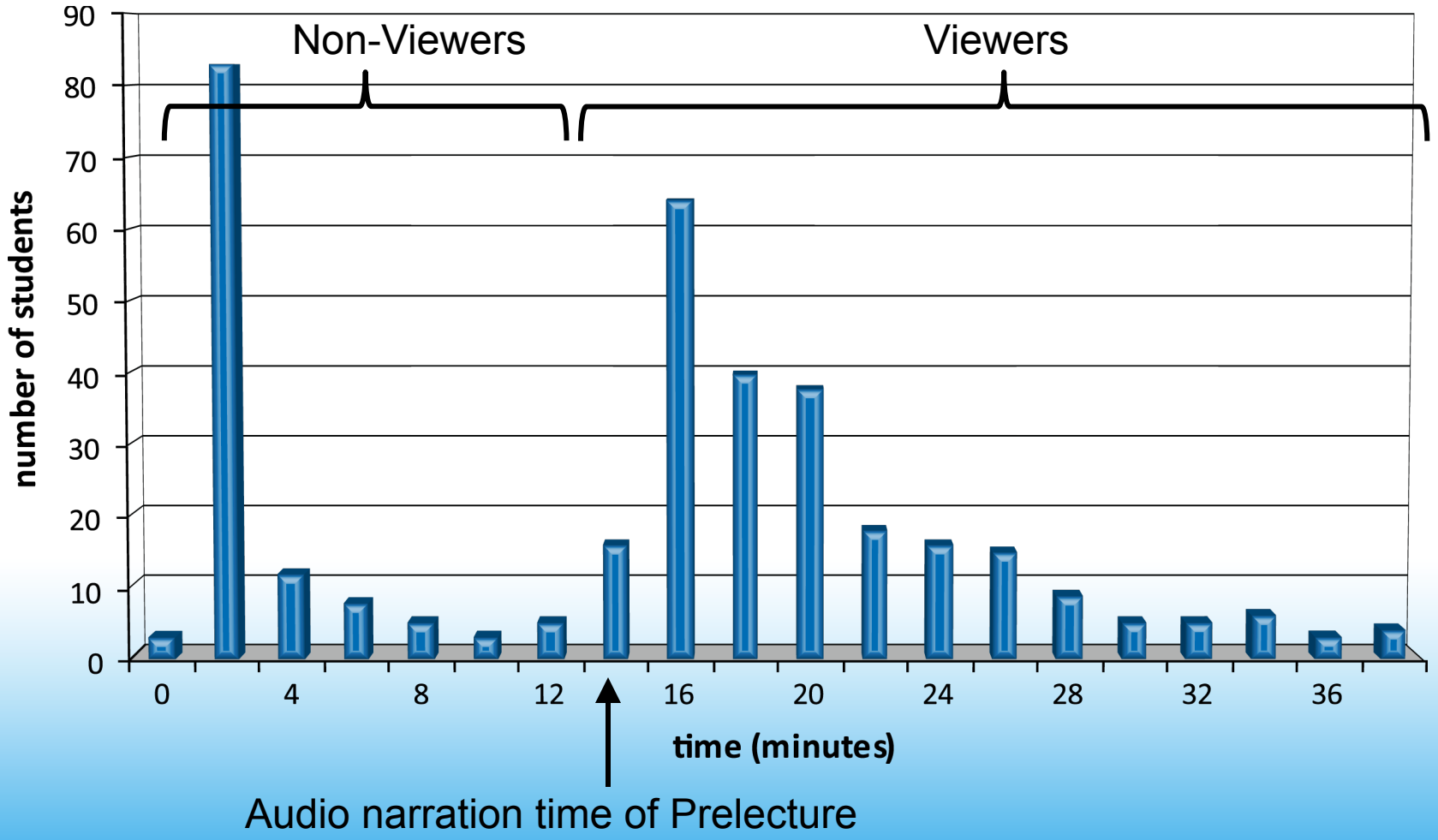
### Before Flip




### After Flip



# Viewers vs. Non-Viewers



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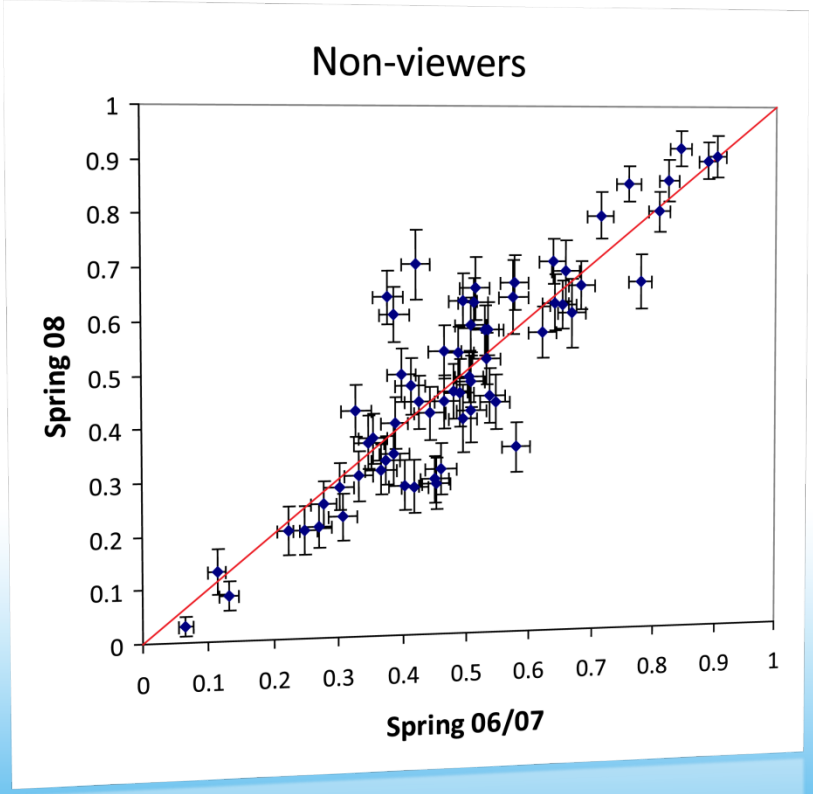
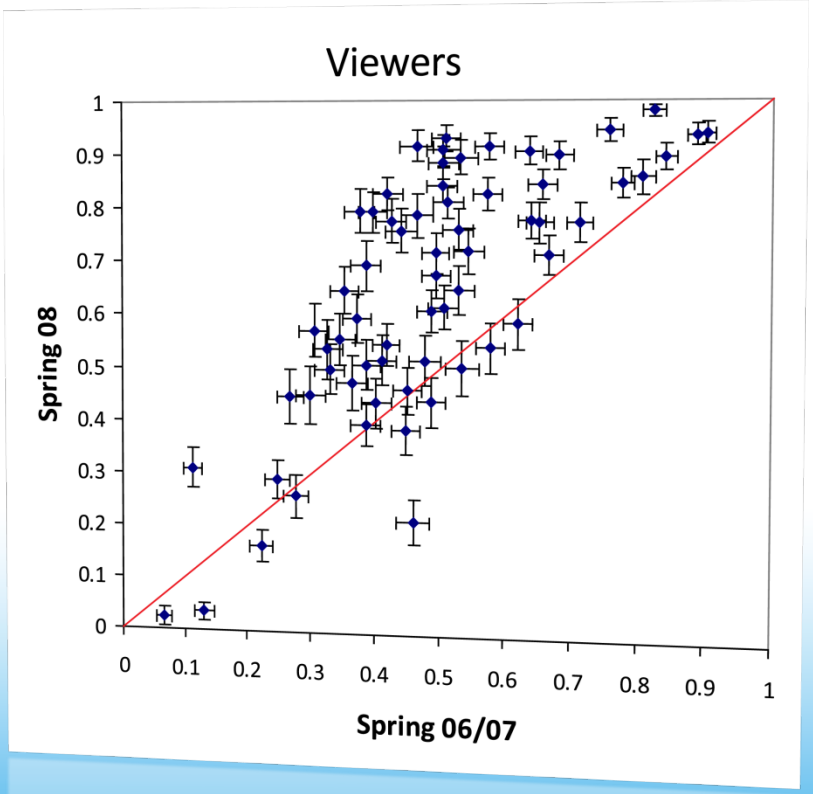
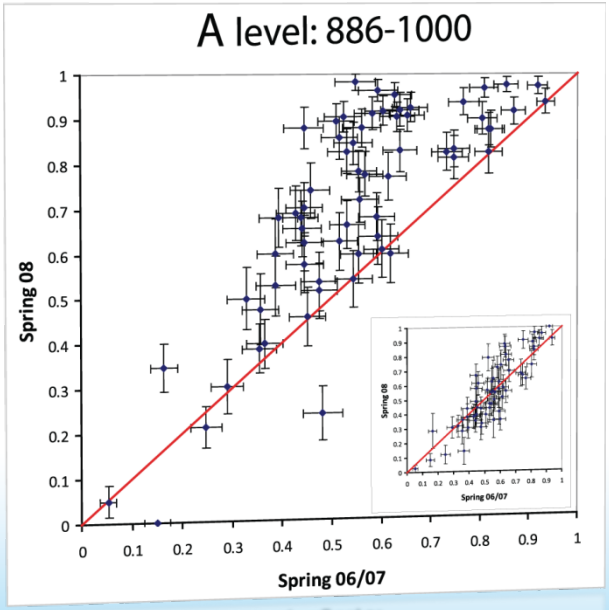
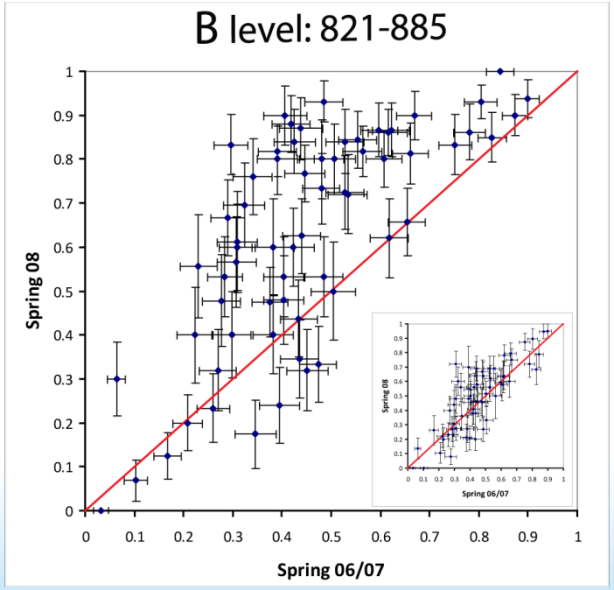


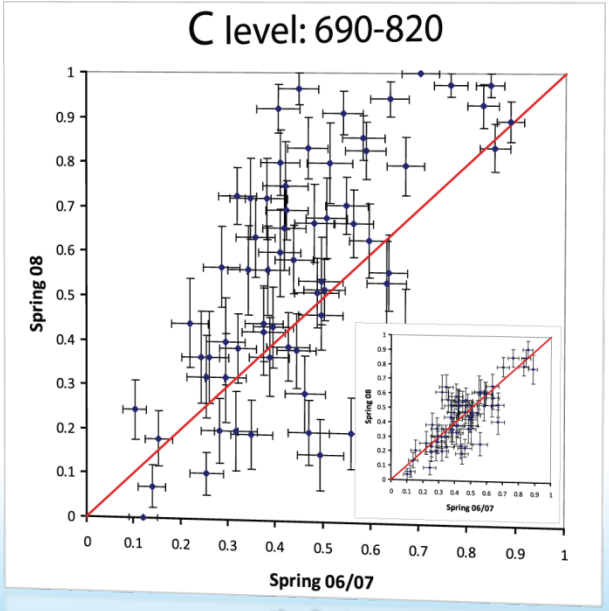



# Checkpoint Study

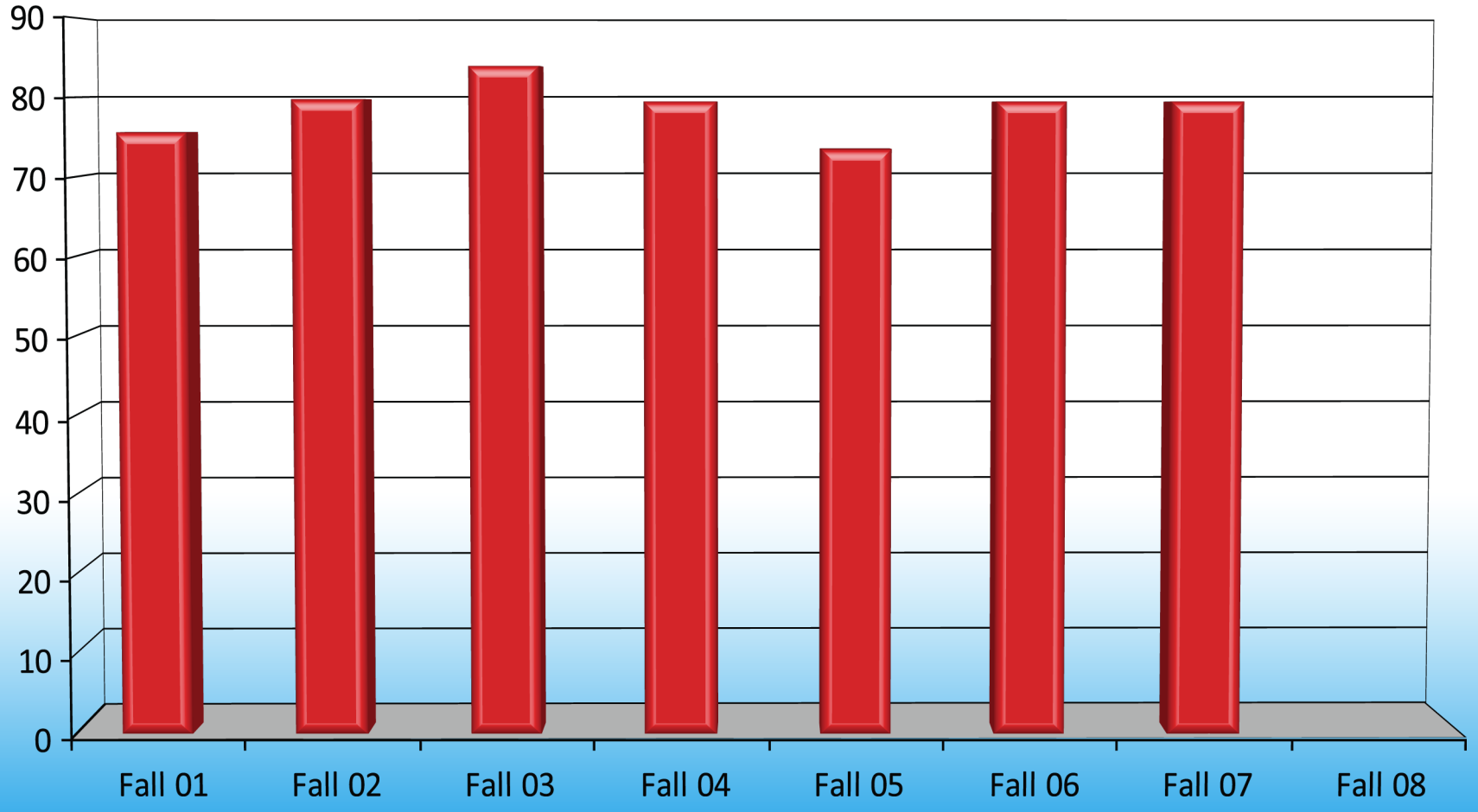
## Significant improvement seen for all students



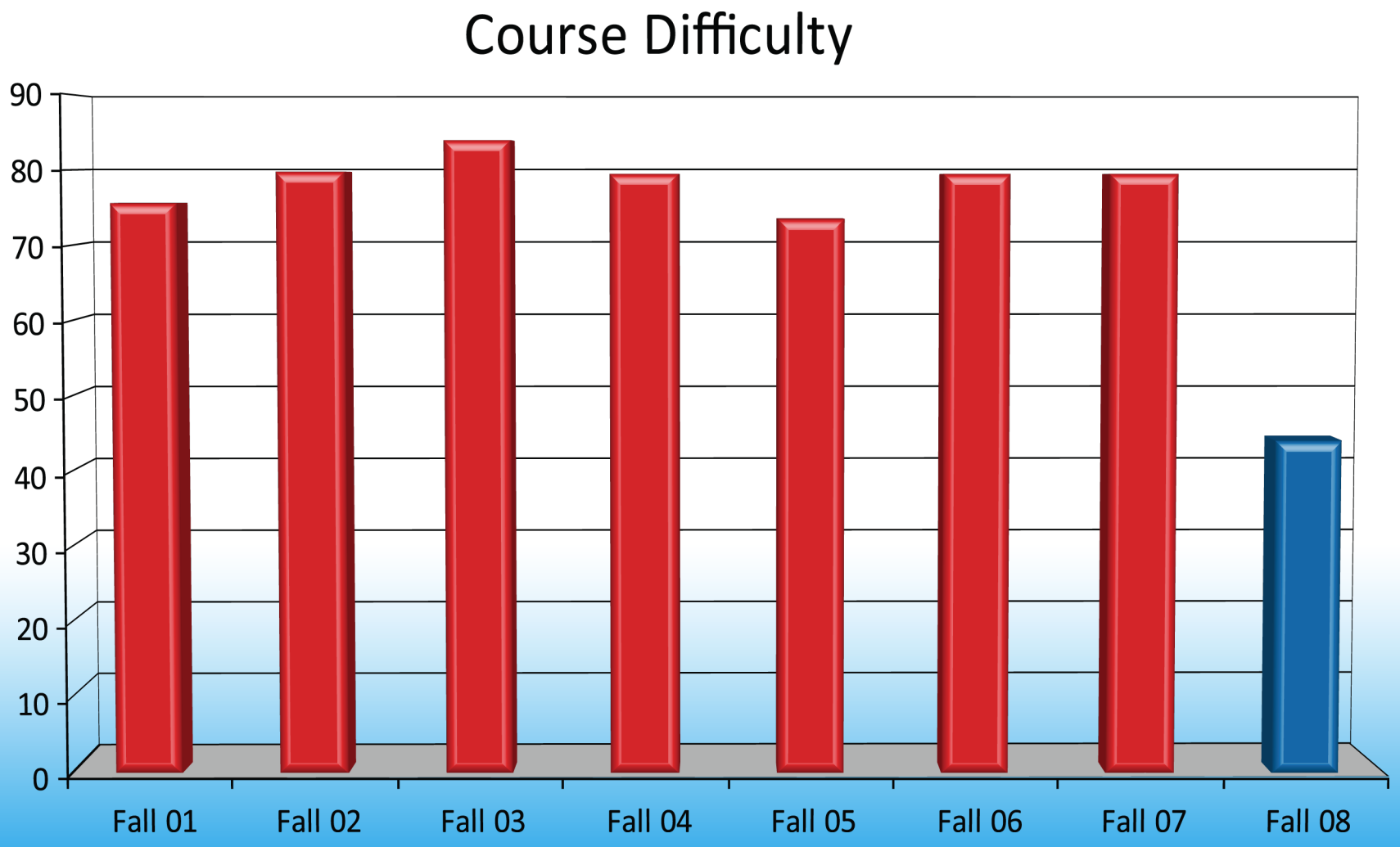



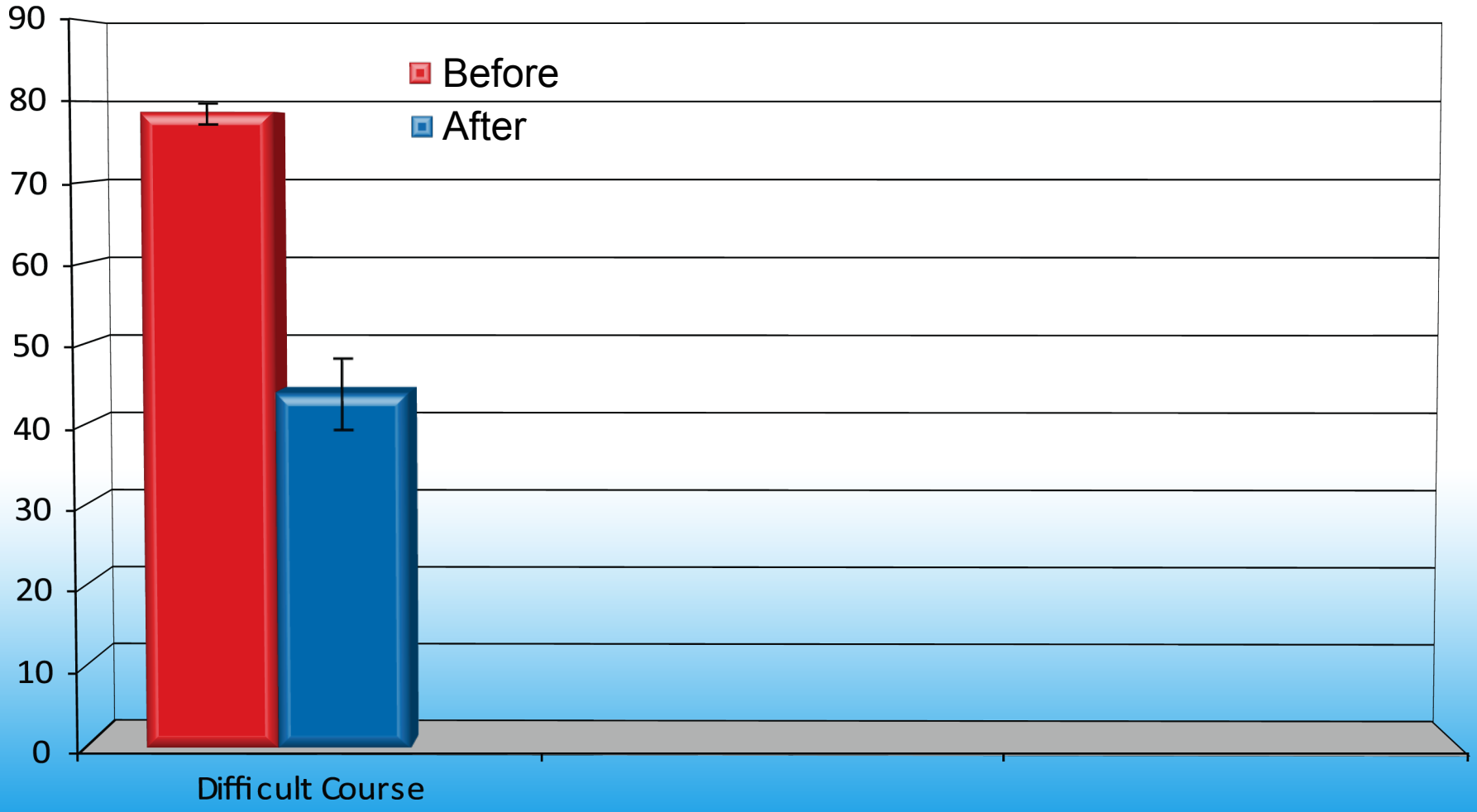
# Course Difficulty



# Changes Made Learning Easier!



# Student Perception of Course



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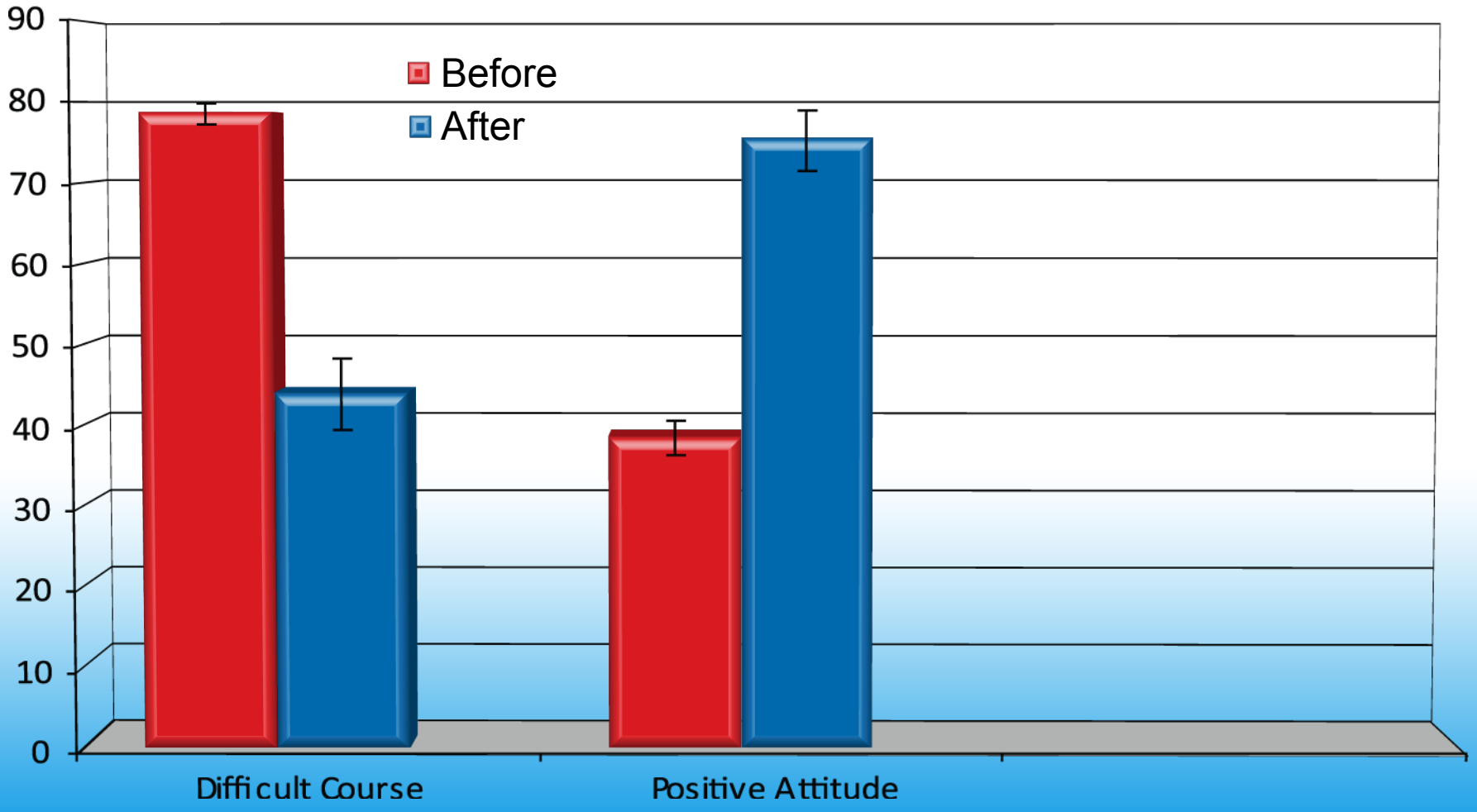
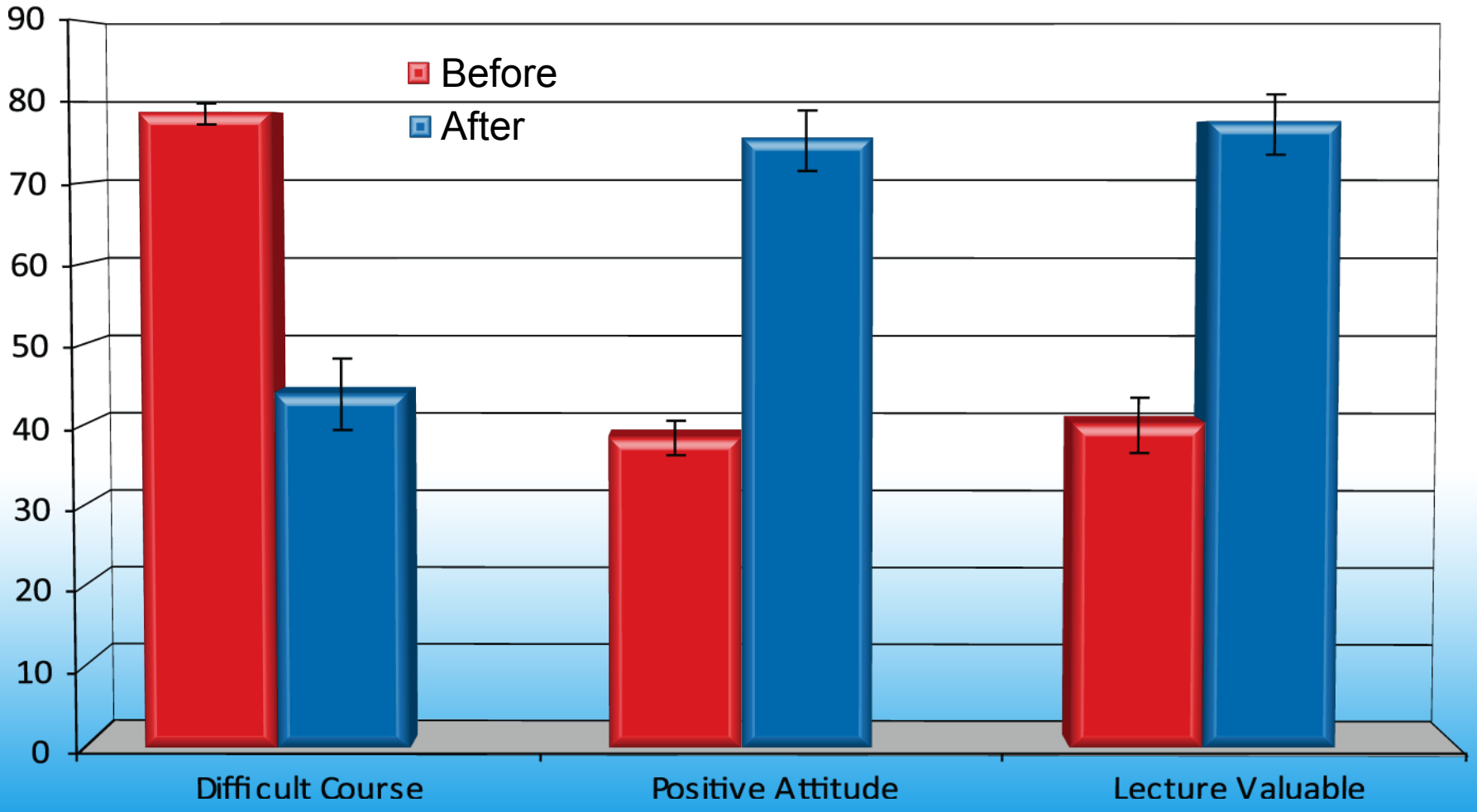


# Student Perception of Course



# What's Next?

## Present Status

Lecture: (50 min) JiTT & Peer Instruction, smartPhysics (good)

Discussion: Peer instruction, trained & mentored TA's (good)

Homework: Online, including Interactive Examples (good)

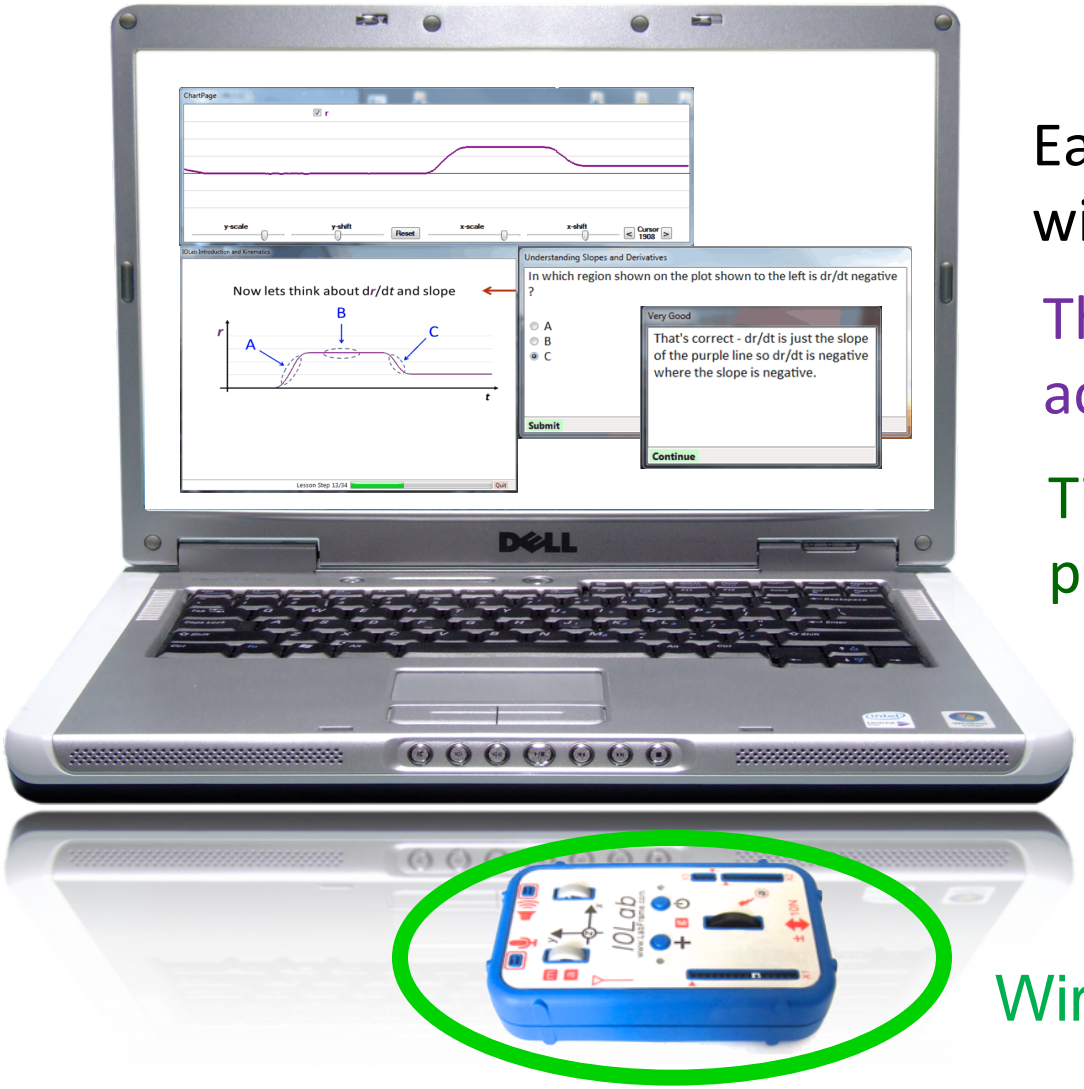
Labs: Group work (traditional) (not so good)(getting worse)

Exams: Multiple Choice (good)

Maybe the following idea could help a bit…

# Interactive Online Labs

## Hands-on activities delivered & graded online.




## The Big Idea:

Each student has their own wireless device (buy cheap).

They are guided through each activity by interactive software.

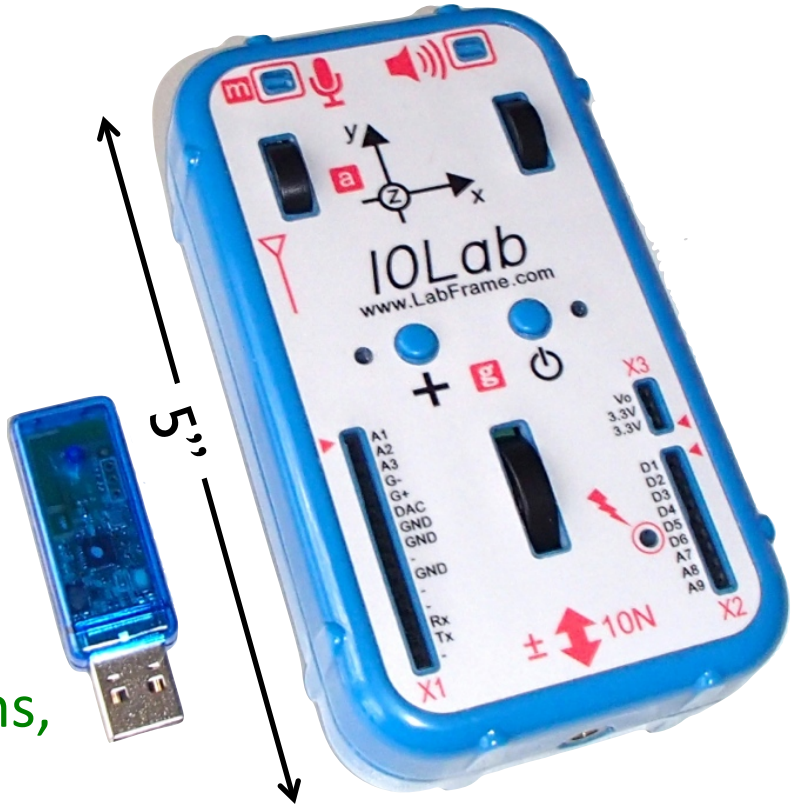
Timing of activities driven by pedagogy, not space/budget.

Not just a simulation…

Wireless DAQ hardware

# Basics

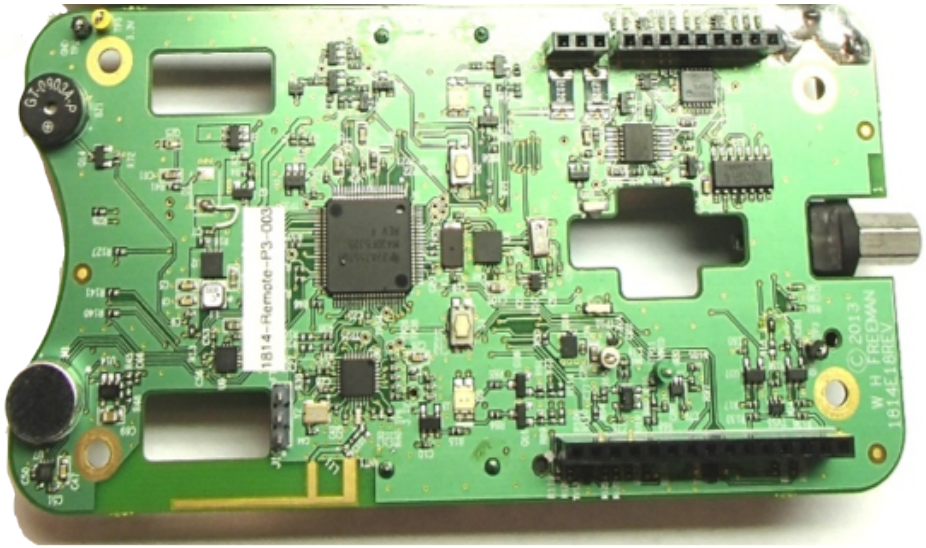
- 2.4 GHz wireless communication with USB dongle (virtual com port).
- Acquires data & sends to PC for display in real time.
- Controlled by PC application which can also display lesson, ask questions, keep score, (think smartPhysics)
- Designed to be opened up, messed with, reprogrammed, (think Arduino)



# Inside

Demo


- 3D accelerometer
- 3D magnetometer (.001 $B_E$)
- 3D gyroscope
- Force probe (± 10 N)
- Position encoder for x, v, a
- Light intensity sensor
- Atmospheric pressure sensor
- Temperature sensor
- Speaker
- Microphone



- DC coupled high gain differential amplifiers w/ external inputs
- Extensive expansion port including ADC in, PIO & DAC out, FTDI
  (First expansion board: High quality ECG)
- High sample rate (up to 5 kHz) with transfer to PC in real time.

# Playing is fun, but we also need to study the best way to use this tool (NSF/TUES).


Our first studies have focused on students working independently, guided by software driven lesson.

# For those of you that didn't see Katie's talk:

## Addressing Conceptual Problems in 1D Kinematics Using Interactive Online Laboratories

Katie Ansell

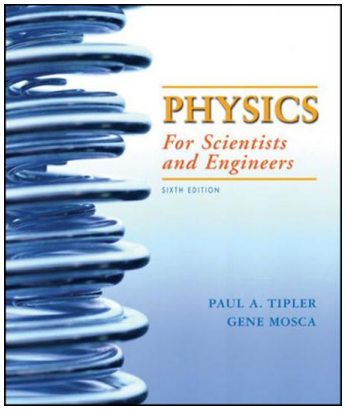
AAPT Summer Meeting

July 15, 2013

# Study - 1D Kinematics Review

## Reading Group

N=25




Mathematical explanations

14 numerical examples

Figures of graphed motion

30-35 minutes

## IOLab Group

N=22

Training plus three guided activities

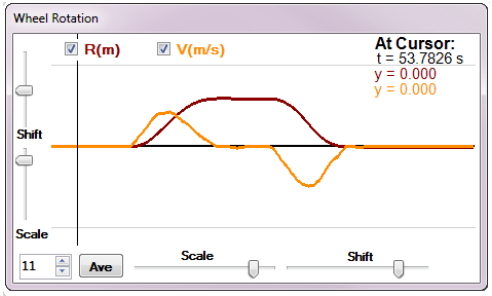
Students asked to make predictions

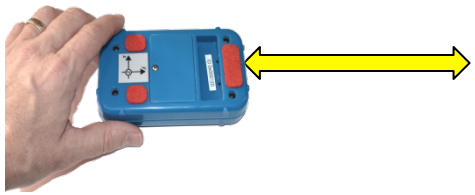
Integration tool

10-15 minutes

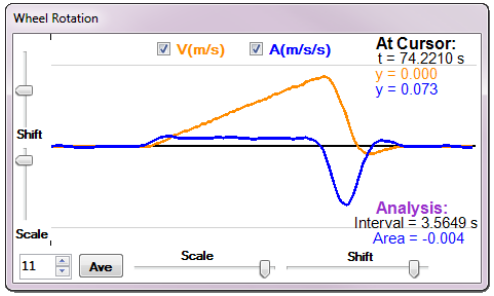
# Goal 1: Address Situational Difficulties

## Turning Around 1

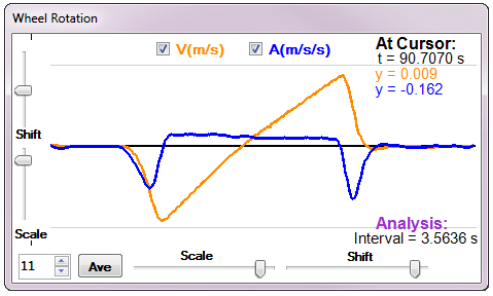


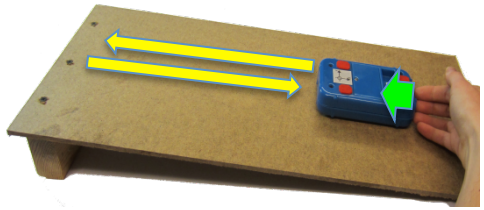



## Speeding Up
(constant a)

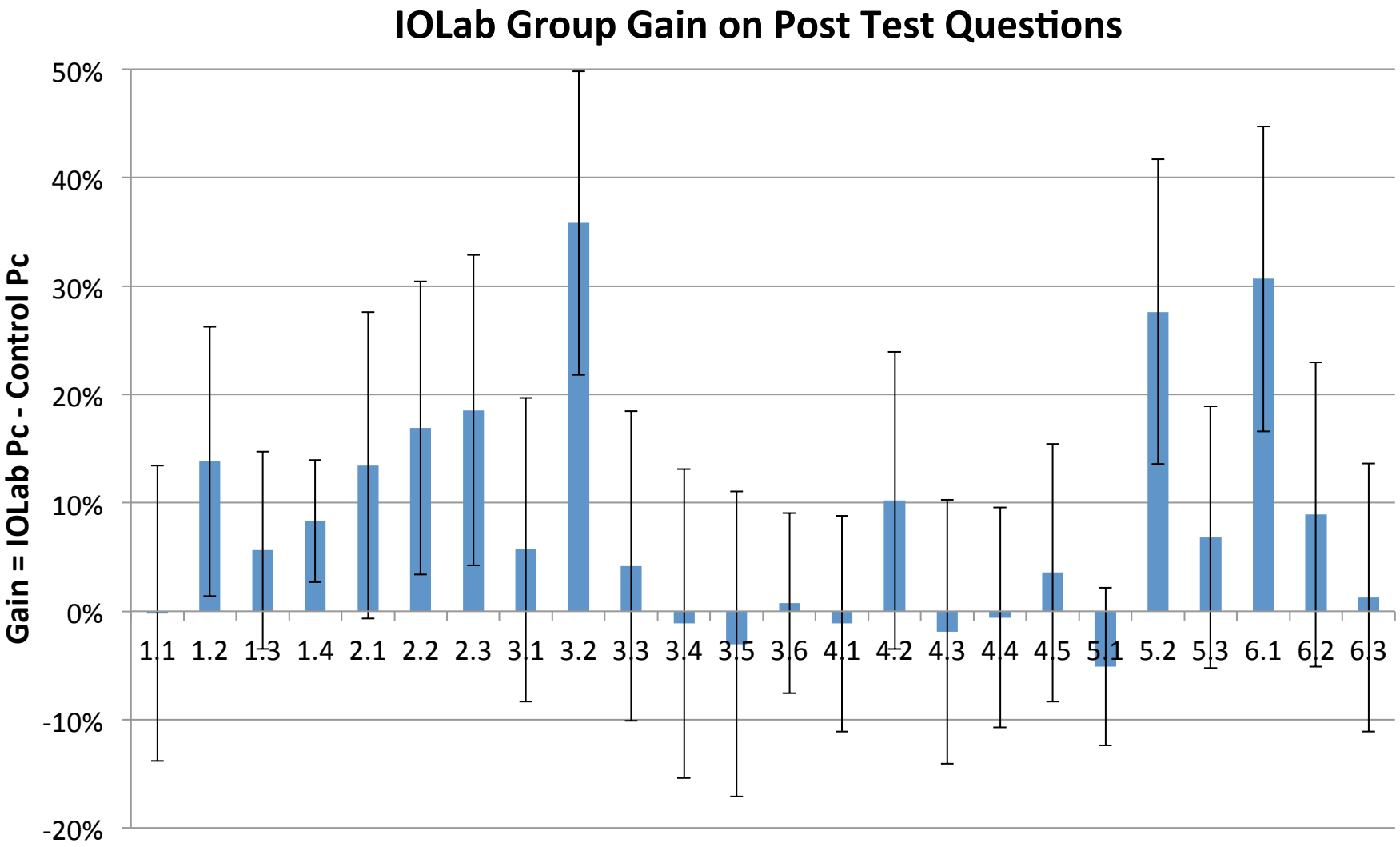



## Turning Around 2
(constant a)

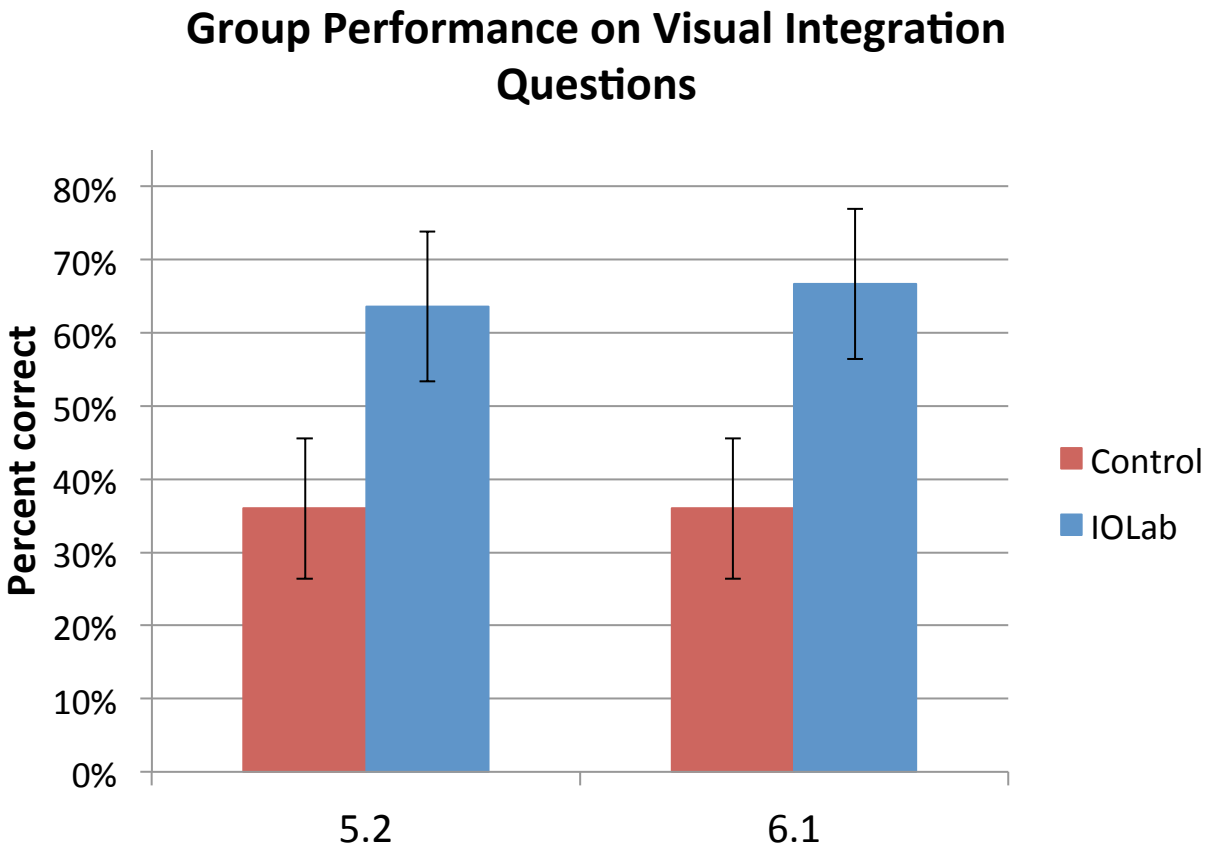


# Post Test – Overall Learning Gains



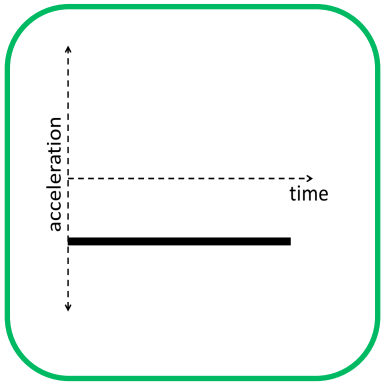
# Improved Graph Interpretation

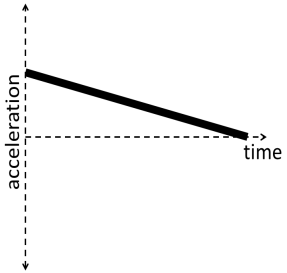


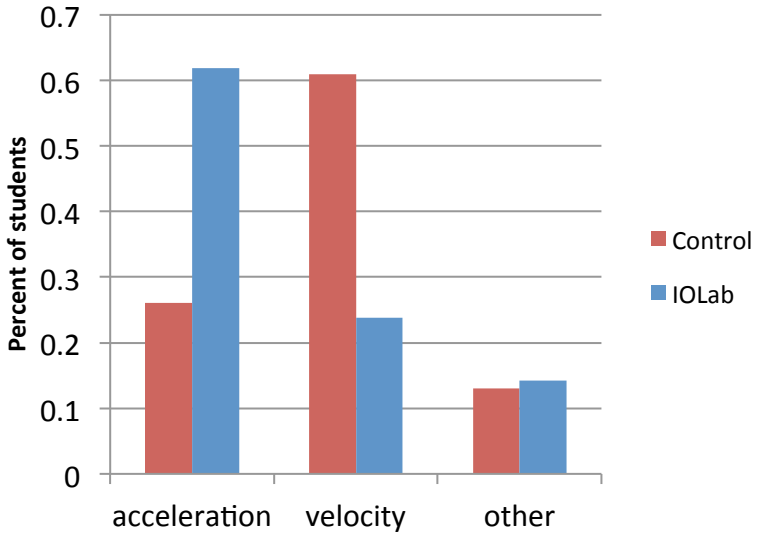
# Less likely to confuse velocity & accel.

*Choose **acceleration vs time** graph which corresponds to the motion of the car:*

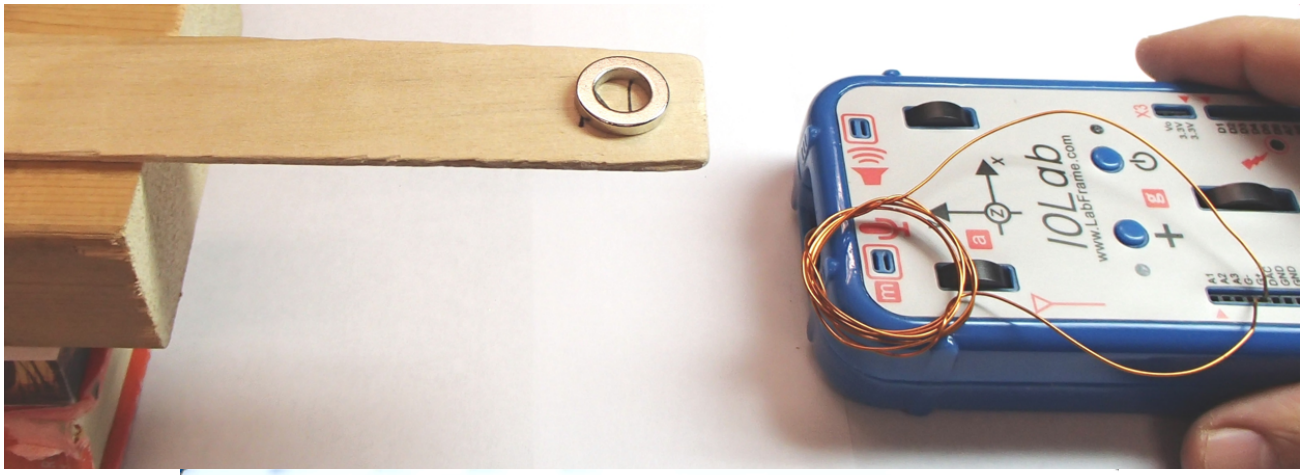
The car moves toward the right, slowing down at a steady rate.

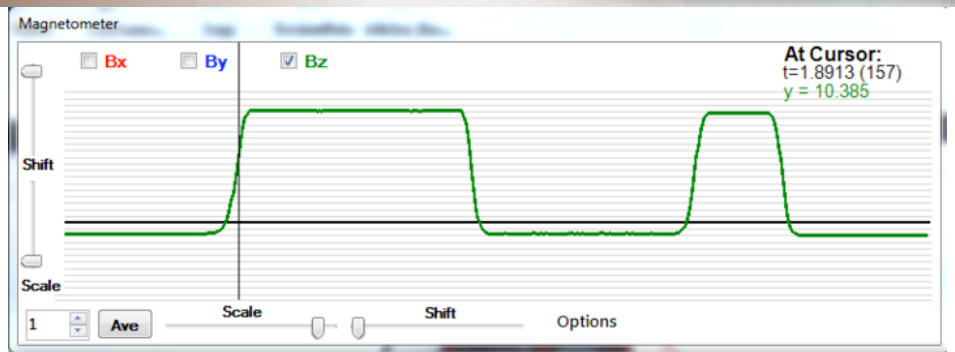


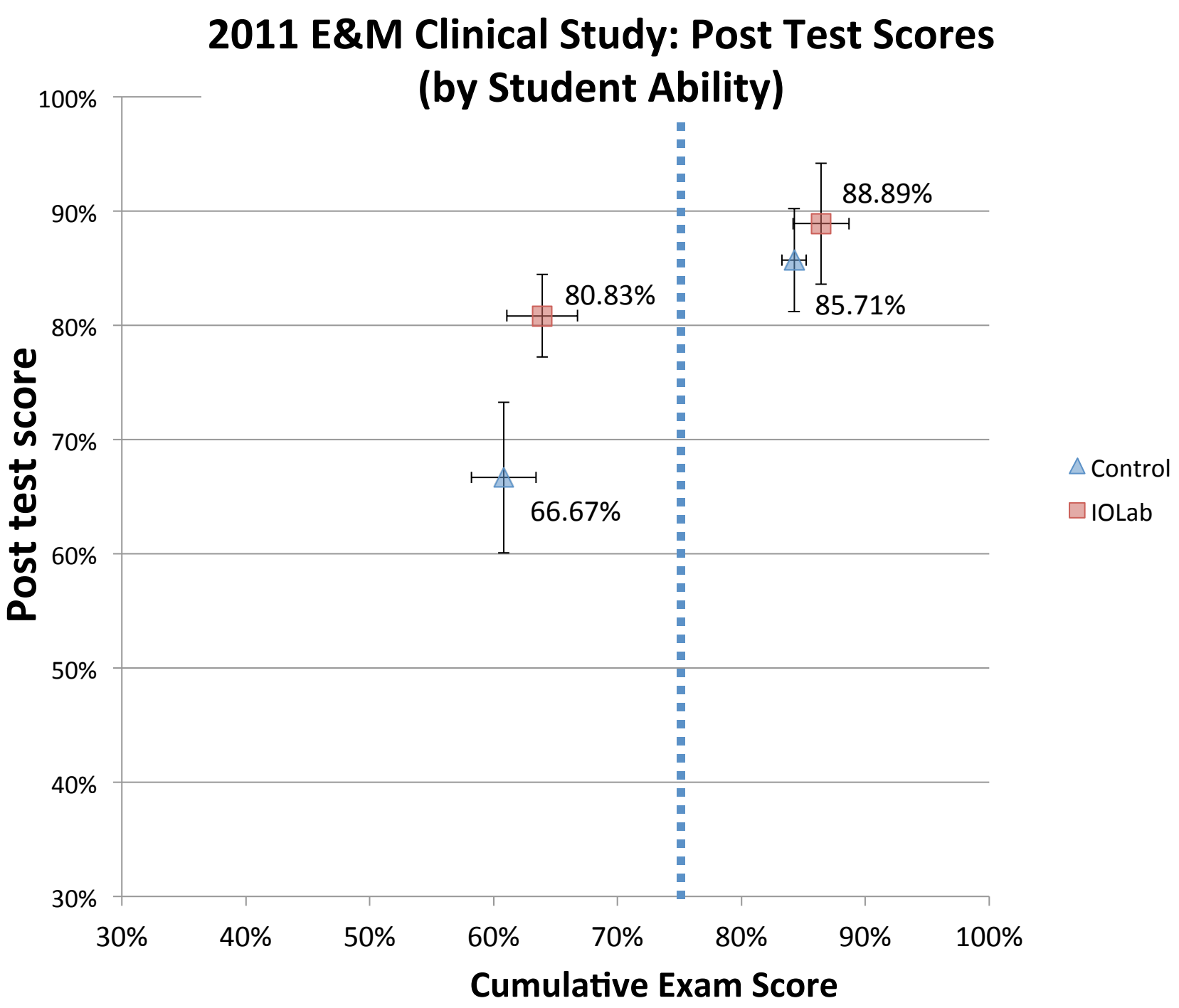



# Not just mechanics:





2011 E&M Clinical Study: Post Test Scores (by Student Ability)
100%
90%
80%
70%
60%
50%
40%
30%
Post test score
88.89%
80.83%
85.71%
66.67%
Control
IOLab
30%
40%
50%
60%
70%
80%
90%
100%
Cumulative Exam Score

Physics Education Research

# Key Messages

- Infrastructure enables innovation.
- There are research validated teaching techniques that simply work better than the traditional lecture !
  - Prelectures (the Flip)
  - Checkpoints (JiTT)
- There are now convenient & powerful tools that allow you bring this to your class without a heroic effort.
  - smartPhysics (byteShelf)
- Technology is allowing us to explore new low-cost ways of providing hands-on experimentation outside the classroom.
  - IOLab