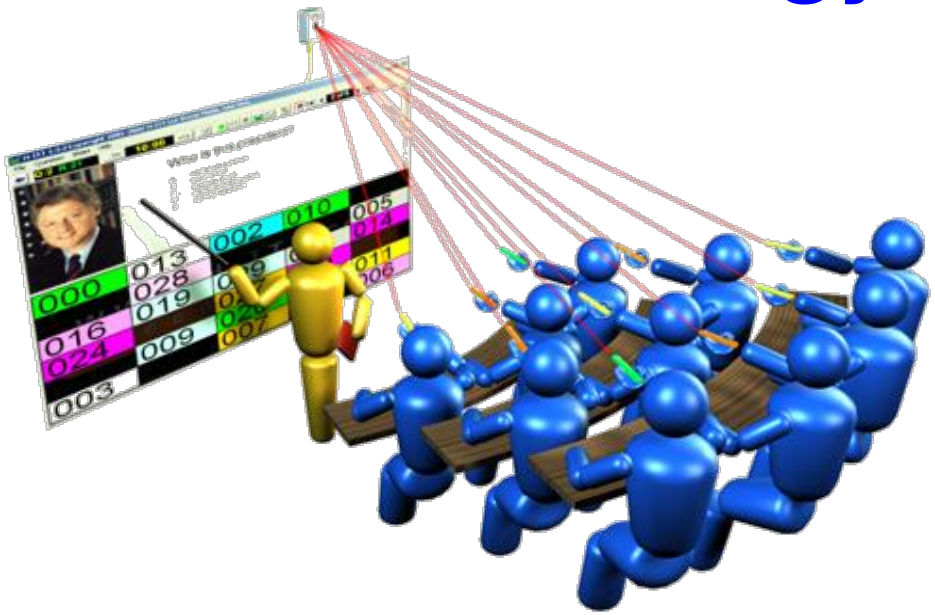
Teaching Undergraduate Physics Through a Research-based Clicker Methodology



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Background & Motivation

- Traditional physics teaching
  - Cost effective, learning inefficient
  - One way communication: **Teacher ➔ Students**
  - Lack students' active participation



Leonard et al., Concept-based problem solving (1999)

Students learn more from what they do than what they hear!

Background & Motivation

- Clickers: wireless handheld devices
- Using clickers improves learning dynamics

They can provide:

Constructivist approach to active learning

Cognitive conflict stimulating dialogue

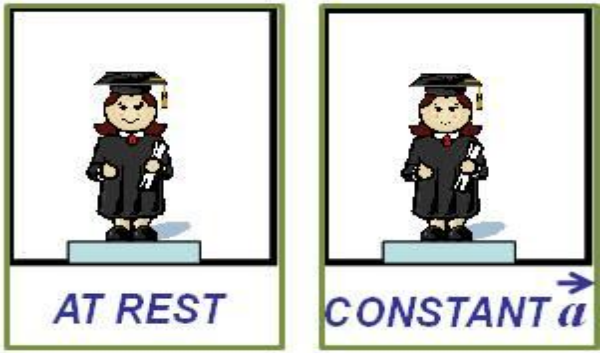
Series of Visual Steps

Real Time Assessment

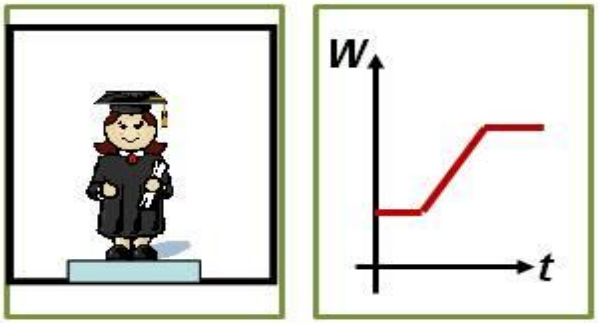
Creation of Clicker Question Sequences

- Research-based concept question sequences
- *Same* concepts with *different surface features*

Different Entity



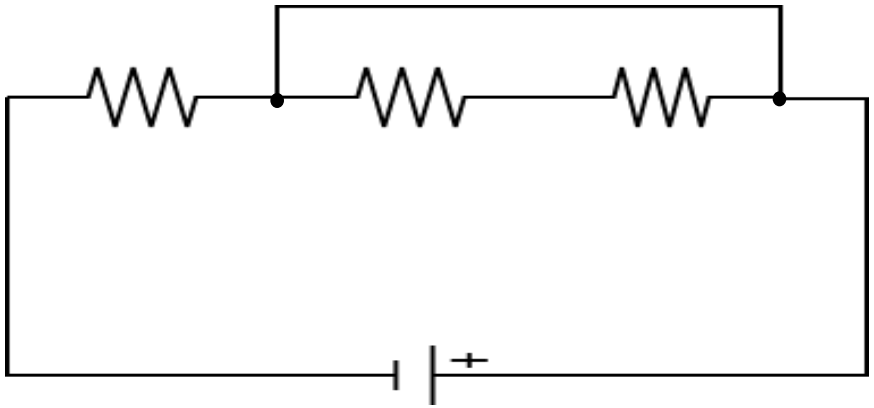
Different Situation



Different Representation

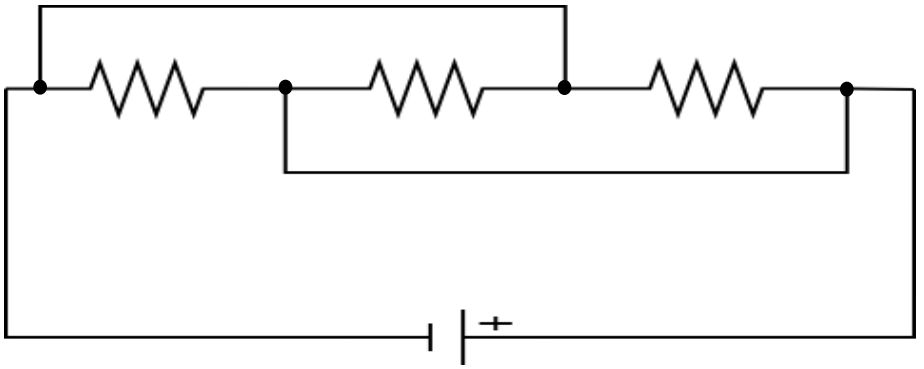
In the following figure all resistors have the same value *R* and the voltage of the battery is *V*. ***Find the total current flow through the battery.***

(*One way to do this is to trace each possible path from one side of the battery back to the other side.*)



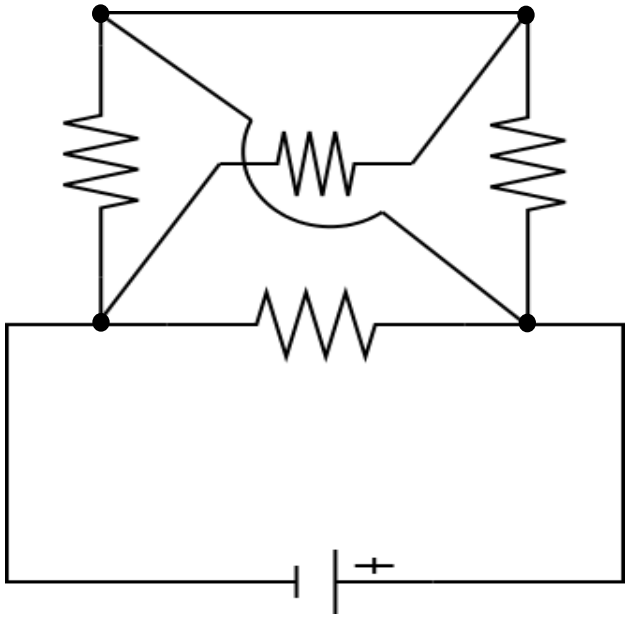
1. *V*/*R*
2. *V*/2*R*
3. *V*/3*R*
4. 2*V*/*R*
5. 3*V*/*R*
6. None of the above

Now, you add one wire to the same circuit as shown. Though there is only one additional wire, there are more paths going from one side of the battery to the other. Find the total current flow through the battery at this time.



1. *V*/*R*
2. *V*/2*R*
3. *V*/3*R*
4. 2*V*/*R*
5. 3*V*/*R*
6. None of the above

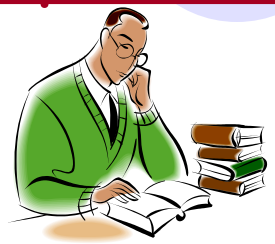
Consider the circuit given below. Each resistor has the same value R and the battery's voltage is V. Find the total current flow through the battery. ***The loop in the diagonal wire means that it loops over the other wire and is connected only on its ends.***



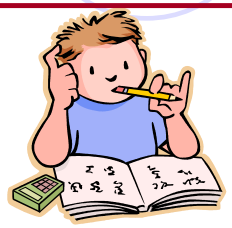
1. V/R
2. $V/2R$
3. $V/3R$
4. $2V/R$
5. $3V/R$
6. None of the above

Validation of Clicker Questions

Expert Review → **Revision** → **Student Interview**



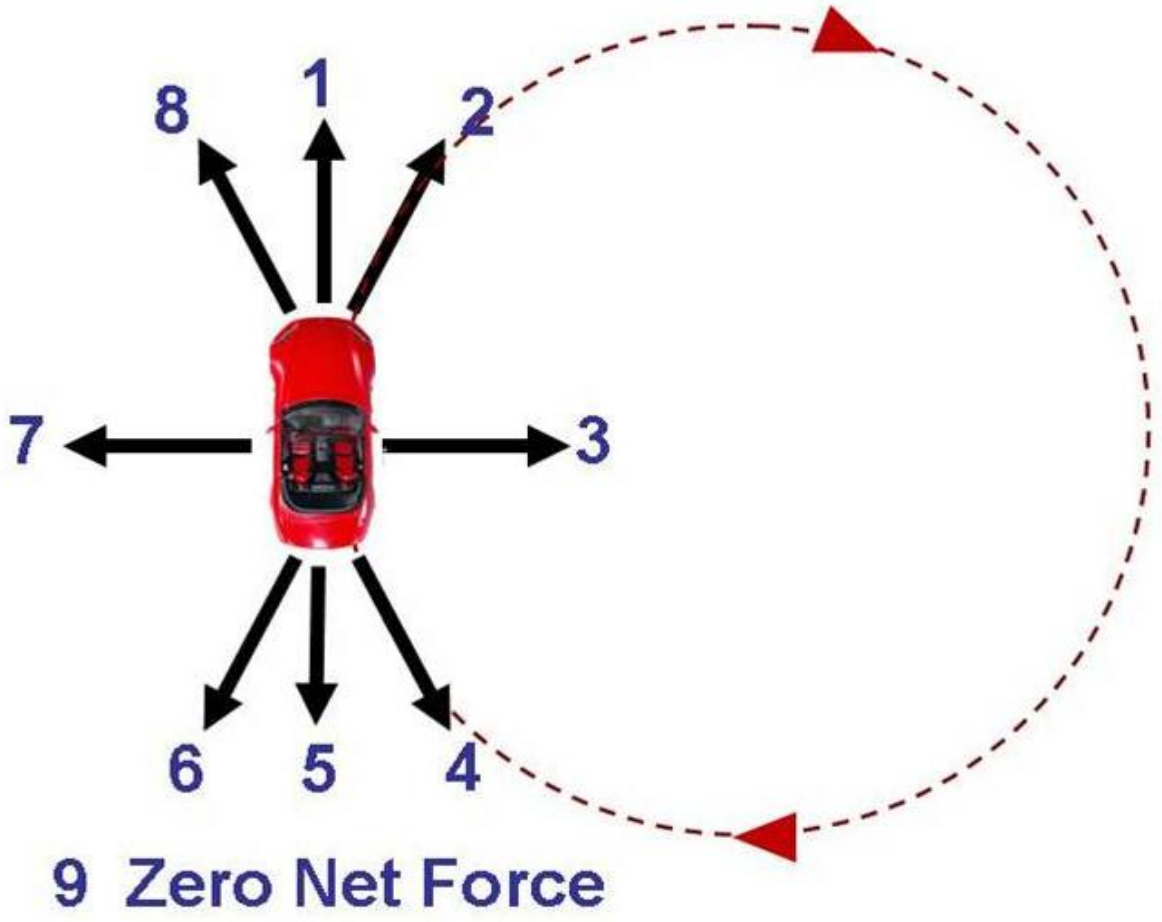




- Expert reviews (physics professors, post-docs & graduate students from several universities)
  - Cover important topics?
  - Contain correct physics?
- Student interviews
  - Frequent view: **Students possess misconceptions**
  - Our view: **Students may not interpret questions in the way intended**

…and sometimes there are unexpected surprises!

A car rounds a curve while maintaining a constant speed. Which arrow represents the direction of the net force on the car as it rounds the curve?



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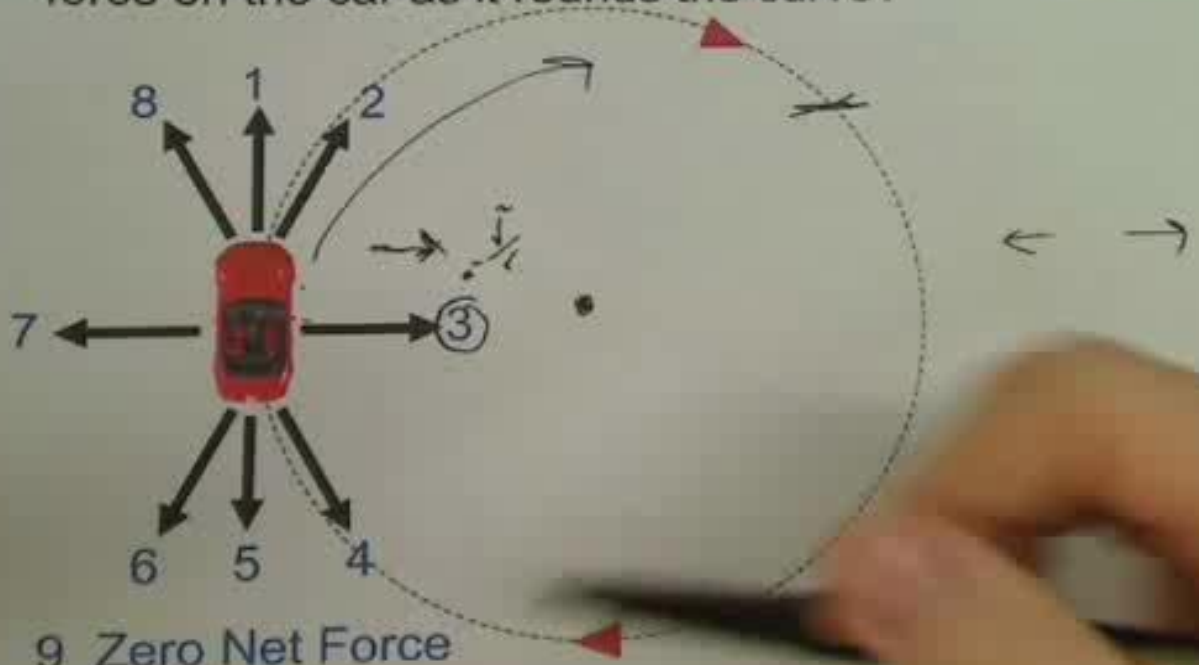
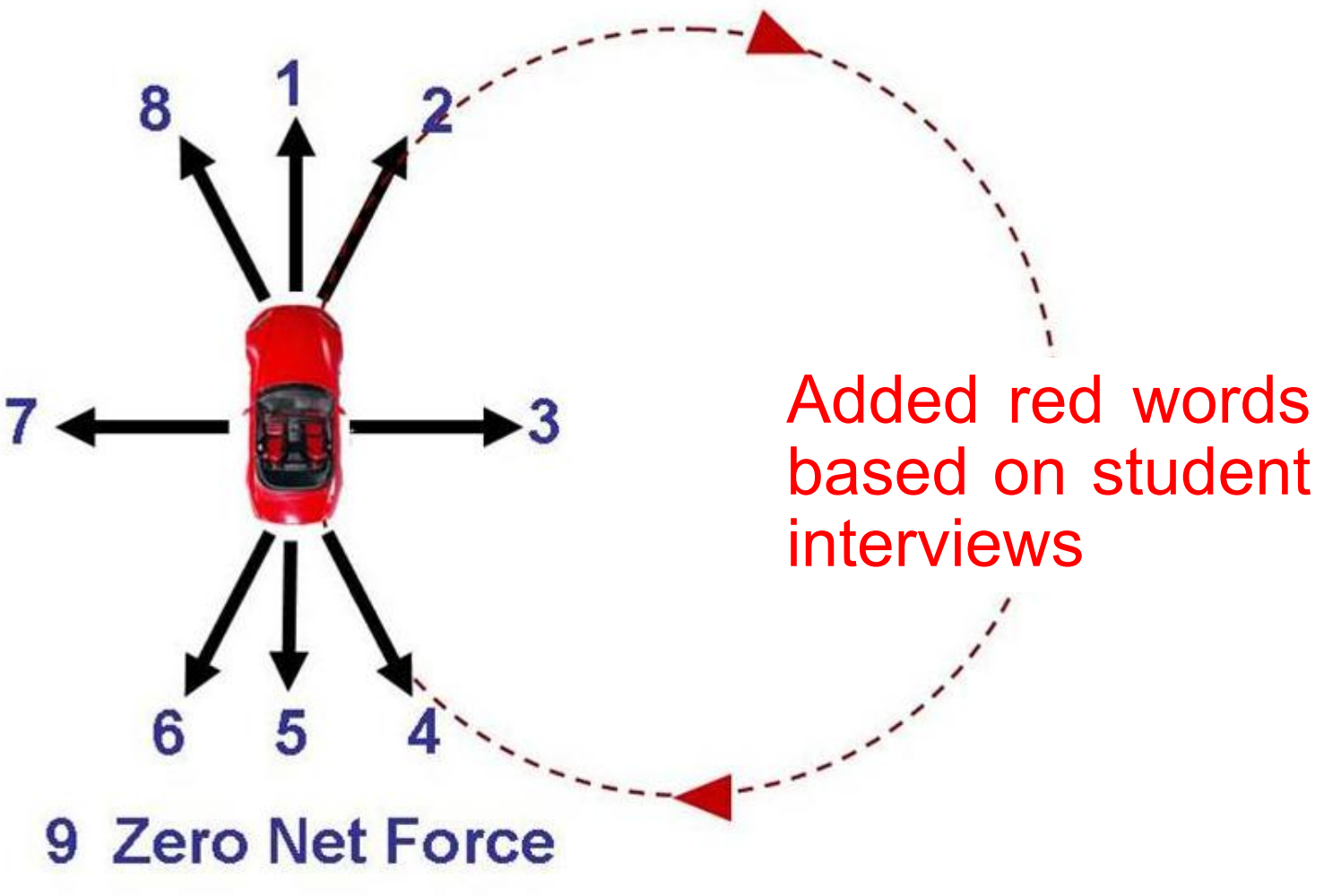
A car rounds a curve while maintaining a constant speed. Which arrow represents the direction of the net force on the car as it rounds the curve?



9 Zero Net Force

48:35:90

A car rounds a curve while maintaining a constant speed. Which arrow represents the direction of the net force on the car as it rounds the curve **at the instant shown below**?

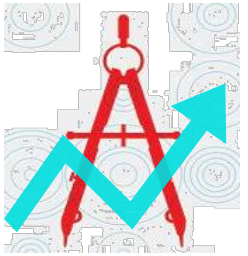


Evaluation of Clicker Sequences

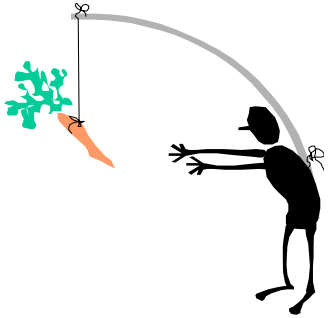
- Compare clicker & non-clicker classes that otherwise are identical
  - Pre-post testing
  - Performance on exam concept questions

- Measure learning gains
  - Normalized gains

$$\text{Norm Gain} = \left(\frac{\text{Post} - \text{Pre}}{\text{Total Questions} - \text{Pre}} \right) \times 100\%$$

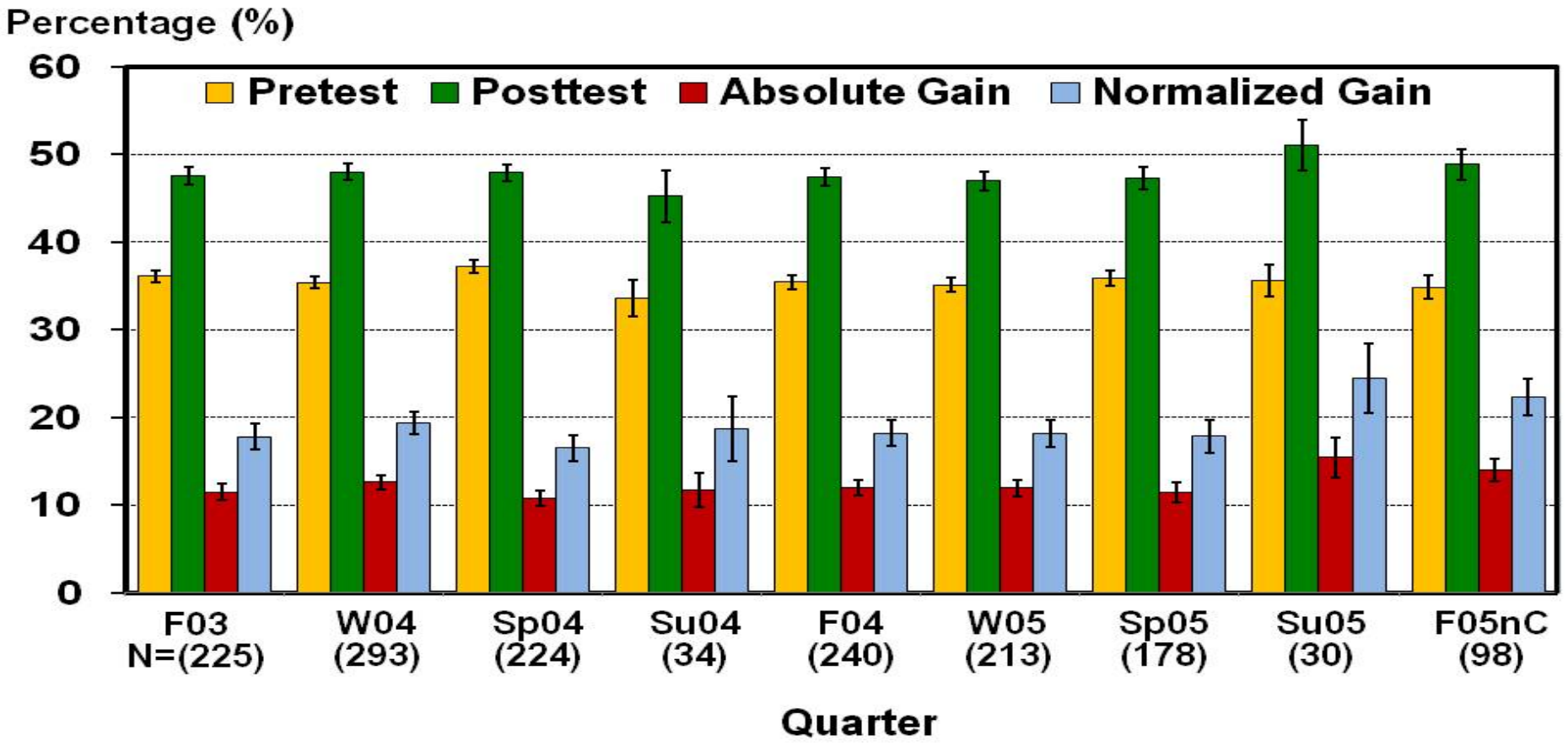


  - Learning gains for Female & underrepresented students
- Influence of test timing & incentives on scores

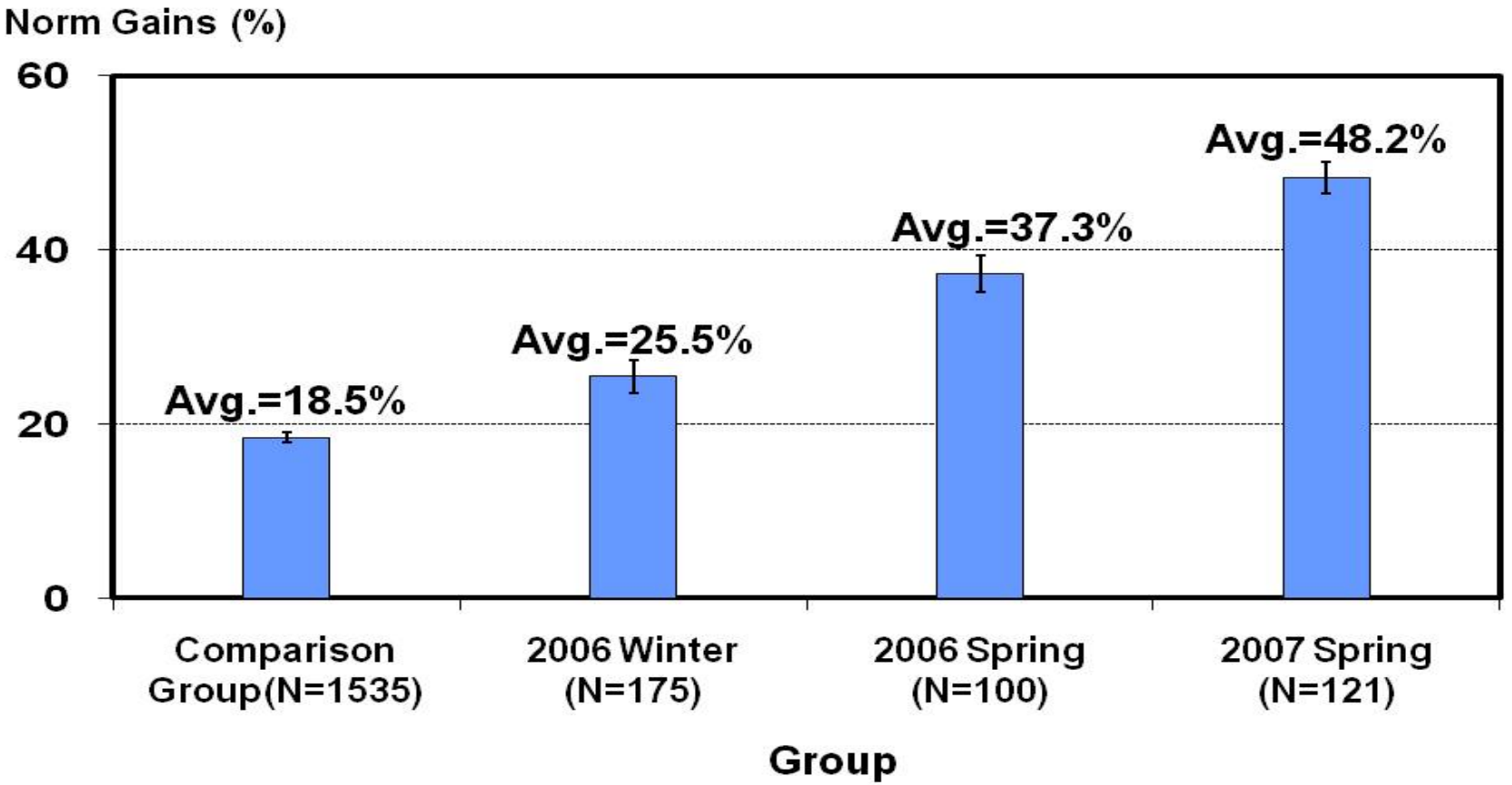


Effects of Testing Conditions on Results (Non-clicker Classes)

- Results from 2 years of previous comparison studies
  - CSEM pre/post in labs without incentives (~80% match)
  - 1575 students, 9 lecturers, 2 texts, 2 HW delivery systems
  - **Pre Avg.**=11.4; **Post Avg.**=15.2; **Norm Gain**=18%



Normalized Gains (Non-clicker Classes)



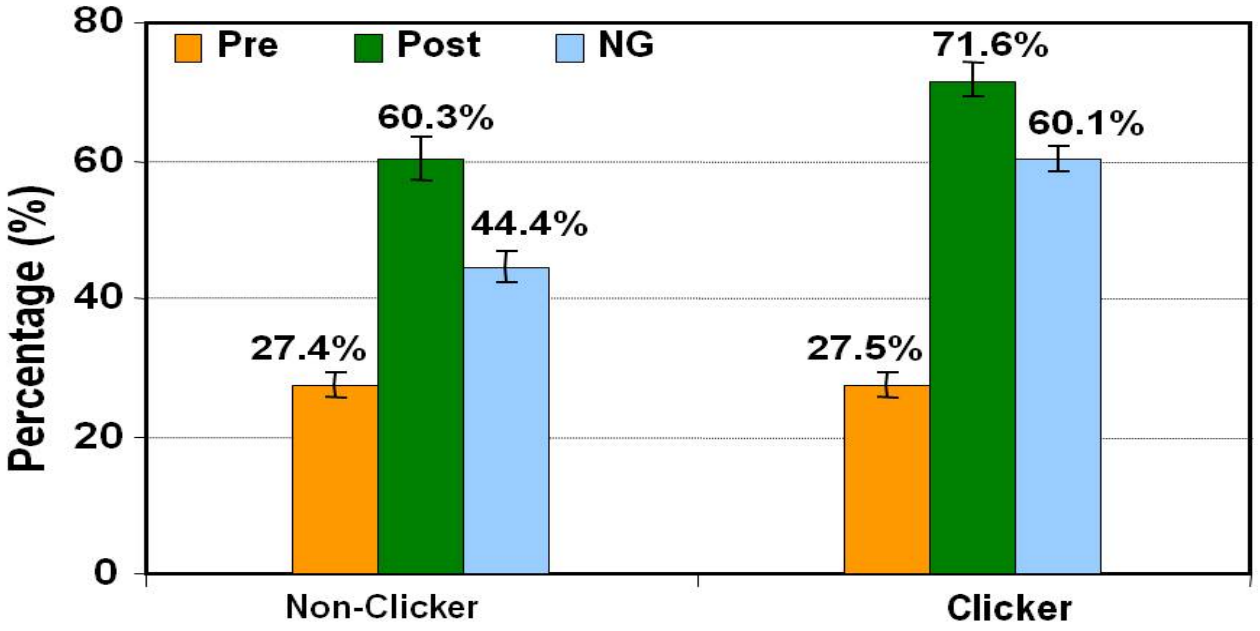
Winter 06: Pretest on 1st day & points for taking posttest

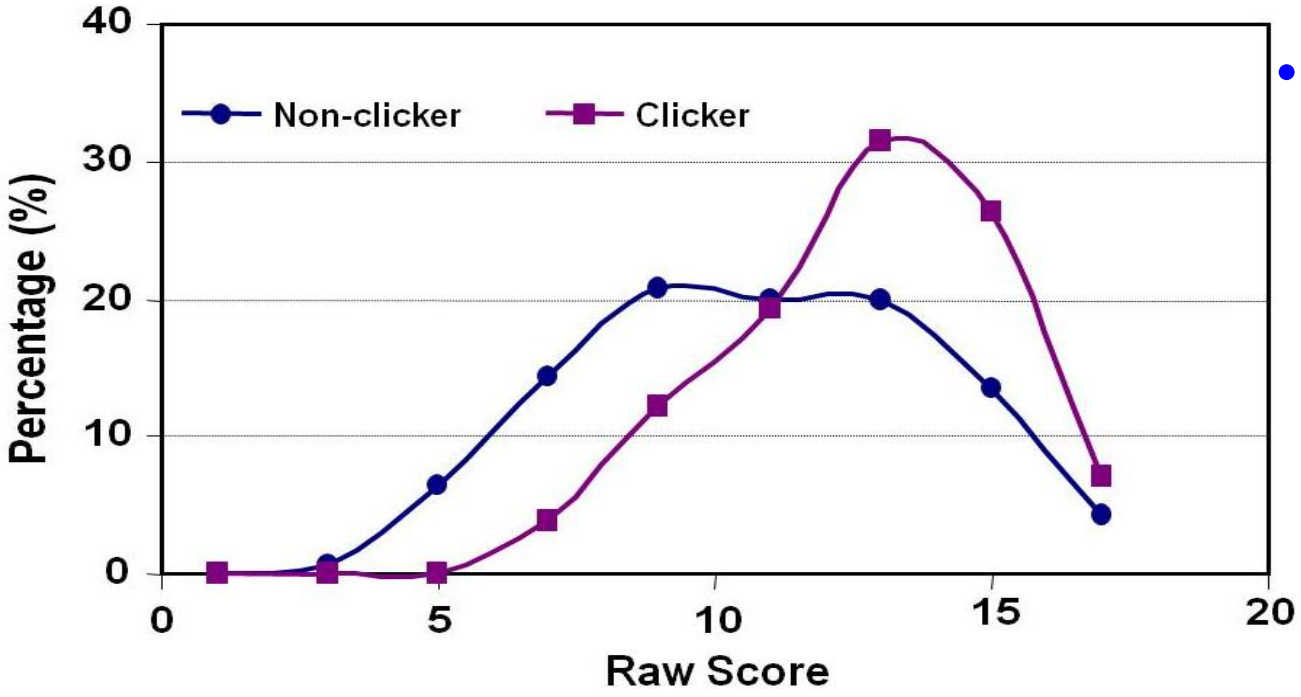
Spring 06: Points for doing well on post test

Spring 07: Post exam on final

But all were the same course.

Evaluation of Clicker Questions: Learning Gains

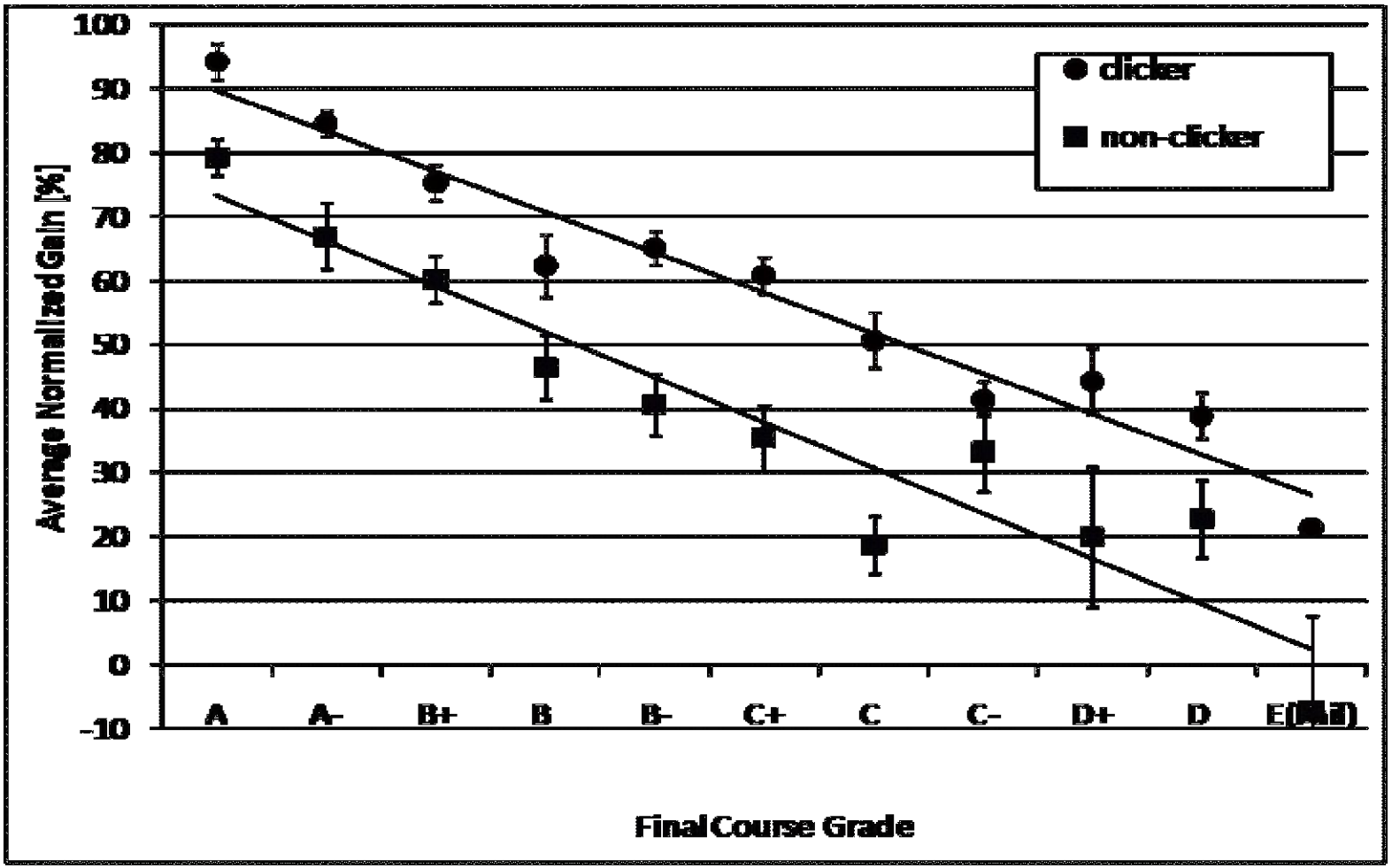




PY 133, Spring 2008

- 17 concept questions
- Pre: before instruction
- Post: on final exam
- Ceiling effect for clicker posttest

Learning Gains for Students of All Levels

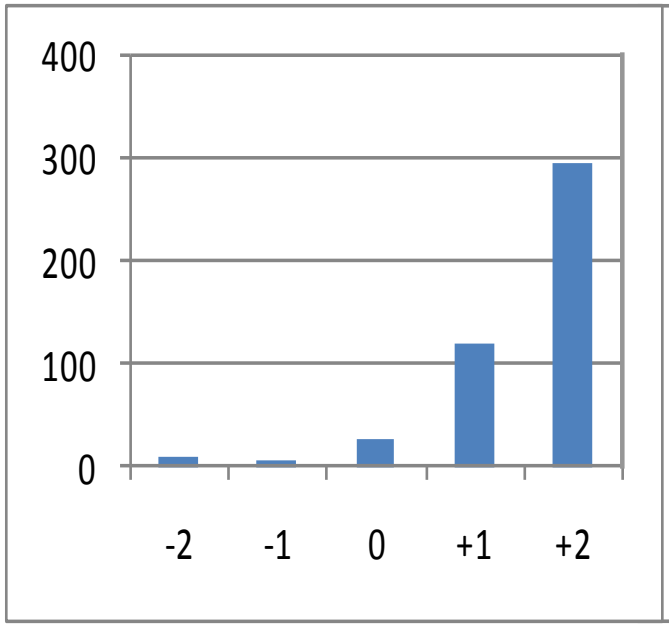


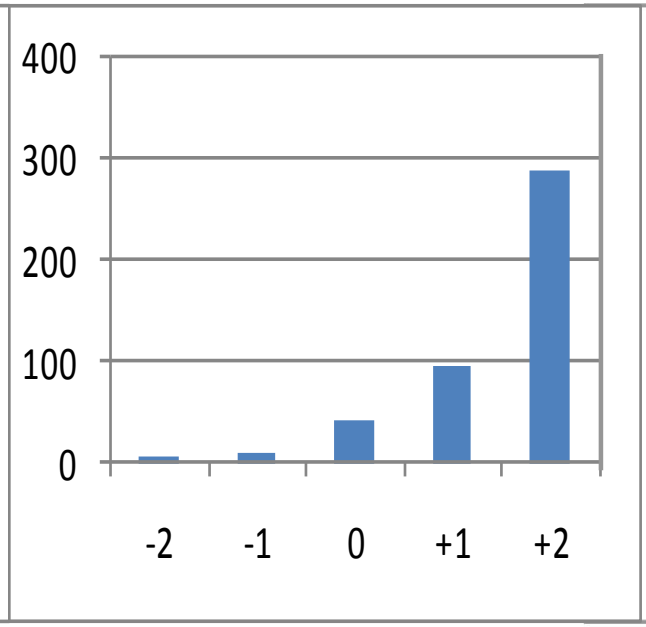
PY133, Spring 2008

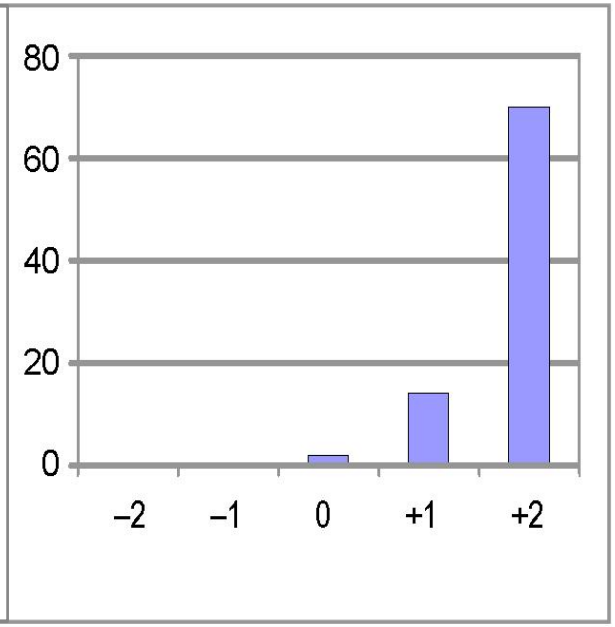
Term	Normalized Gains (%)		p value (t-test)	Effect Size
	Clicker	Non-clicker		
Mechanics (Fall 2007)	28.5 (N = 184)	22.7 (N = 171)	2.6×10^{-5}	0.44
E&M (Spring 2007)	52.0 (N = 106)	48.4 (N = 122)	0.25	0.15
Modern Physics (Spring 2008)	60.1 (N = 156)	44.4 (N = 140)	8.6×10^{-8}	0.64

Evaluation of Clicker Questions: Affective Results

– Students like clickers







Clickers made me feel involved in the course. (Avg. = 1.49)

I would recommend using clickers in all future intro. physics courses. (Avg. = 1.49)

I like using clickers. (Avg. = 1.79)

– 91% of attending students vote (98% with modest incentive)

What's Next?

- Connect ***conceptual understanding*** with ***problem solving***

- Develop effective teaching materials
  Synthesis problems, conceptual scaffolding

- Seek cross-discipline, cross-institution and cross-nation collaborations

Are you interested in learning more?

- Understand fundamental research questions
- Collaborate in future studies
- Implement our research-based clicker question sequences
- Obtain more resources

For more information

Email me: ding.65@osu.edu