

# Clickers in Upper-Division Courses

**Stephanie V. Chasteen**

Kathy Perkins

Michael Dubson

Steven Pollock



*Physics Dept. and Science Education Initiative*

University of Colorado at Boulder

AAPT Feb 2009  
Chilly Chicago

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Clicker Use in Upper-Level Courses

Univ. of Colorado  
Breezy Boulder



# CU Physics Education Research

## PER faculty & Research PI's:

**Michael Dubson**

Noah Finkelstein

**Kathy Perkins\***

**Steve Pollock**

Carl Wieman\*

Wendy Adams\*

Valerie Otero (School of Ed)

## Postdocs:

**Stephanie Chasteen\***

**Steven Goldhaber\***

Archie Paulson

Noah Podolefsky

Laurel Mayhew

## Ph. D. students:

Lauren Kost

Chandra Turpen

Ben Spike

Charles Baily

## Non-PER participating faculty

**Paul Beale (chair)\***

**Edward Kinney**

**Oliver DeWolfe**

+ working groups

\* = part of Science Education Initiative

+Wendy Adams

And 12 Teaching Fellows in

5 departments

E&M and Quantum work funded under NSF Grant No. 0737118.



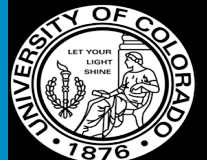
THE WILLIAM AND FLORA HEWLETT FOUNDATION



American Association  
of Physics Teachers

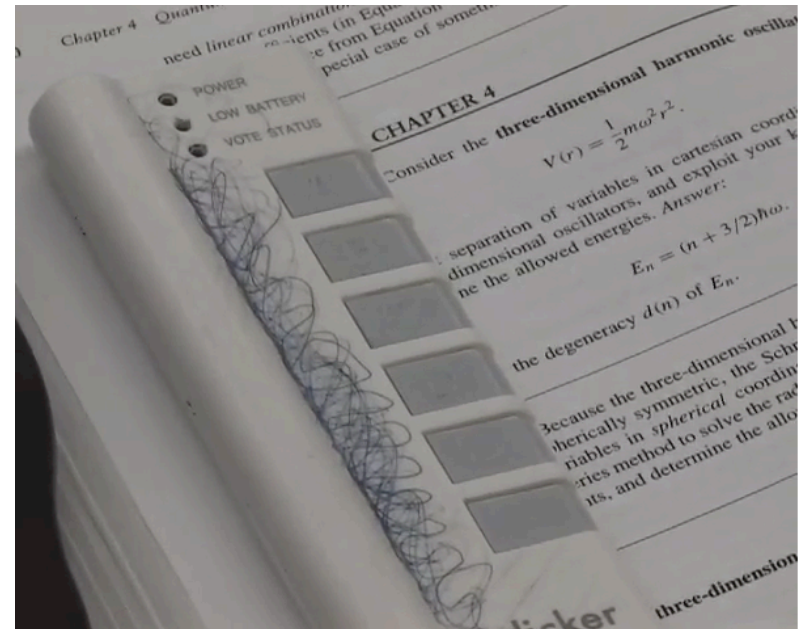


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# Outline

- Step into our classroom...
- Why use clickers in upper-division?
- What does it look like?
- Tips for success



# STEP INTO OUR CLASSROOM...



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# Upper-div Clickers at CU

Course	# times w/clickers	Instructors
Statistical Mechanics	6 (2004-2009)	PER, then non-PER
Solid State	3 (2007-2009)	Non-PER
Classical Mech. I	2 (2006-2007)	Non-PER
Classical Mech. II	2 (2007, 2009)	Non-PER
E&M I	3 (2008-2009)	PER, then non-PER
E&M II	1 (2009)	Non-PER
Quantum I	3 (2008-2009)	PER, then non-PER
Quantum II	1 (2008)	Non-PER
Solid State	3 (2008-2009)	Non-PER
Graduate AMO	2 (2007, 2009)	Non-PER





# Example: Quantum Mech. I

3rd semester of PER-led reforms

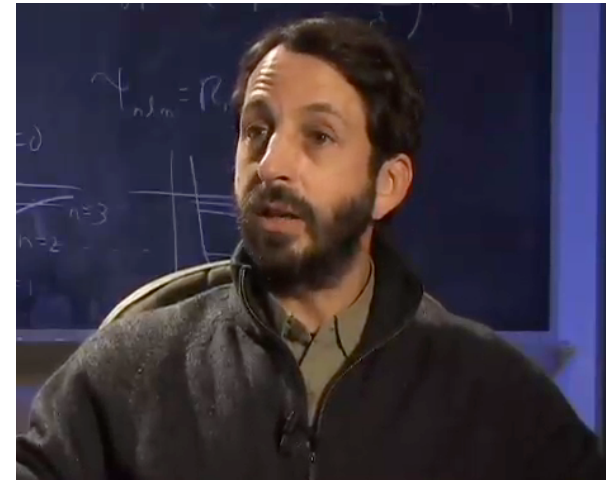
**Steven J. Pollock**

*PER researcher*

Teaching: 15 years

Peer Instruction: 10 years

***Expert clicker user***



Oliver DeWolfe

*Prestigious string theorist*

Teaching: 3 years

Clicker use: first year

***Open-minded new user***

Video:  
Upper  
division use



# Video: Clickers in upper division courses

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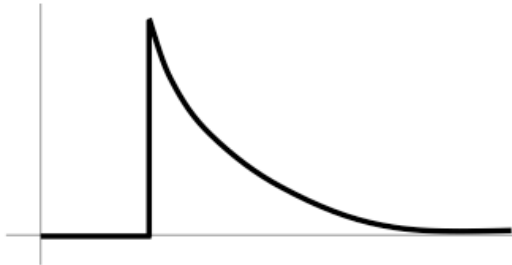
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# Example Questions

2.44



Could this be a plot of  $|E|(r)$ ? Or  $V(r)$ ? (for SOME physical situation?)

- A) Could be  $E(r)$ , or  $V(r)$
- B) Could be  $E(r)$ , but can't be  $V(r)$
- C) Can't be  $E(r)$ , could be  $V(r)$
- D) Can't be either

In general, given Hermitian operators  $A$  and  $B$ , and a state  $\psi$ , (and with the usual notation  $\langle A \rangle = \langle \psi | A | \psi \rangle$ ) what can you say about

$$\langle \psi | \langle A \rangle B | \psi \rangle = ?$$

- A)  $\langle AB \rangle$
- B)  $\langle BA \rangle$
- C)  $\langle B \rangle \langle A \rangle$
- D) MORE than one of these is correct!

correct!

*More examples  
in handouts at  
back and on web*

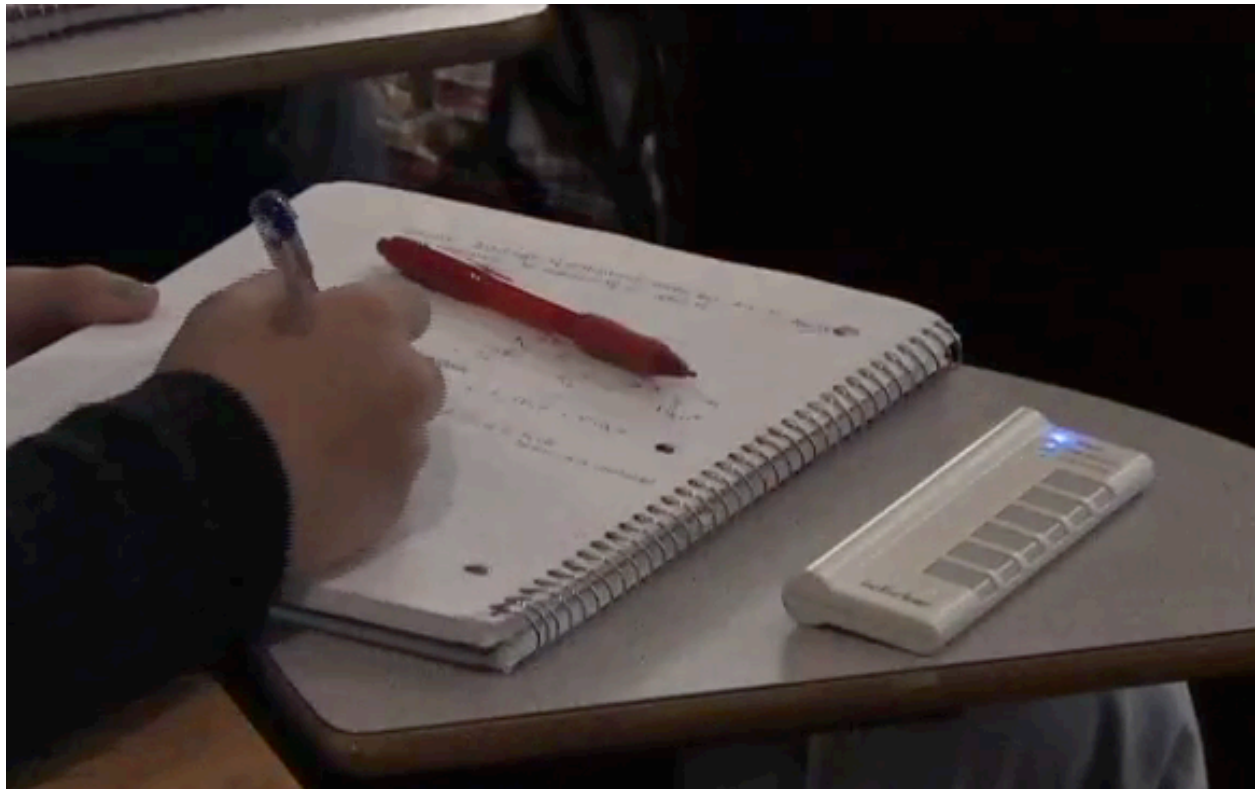
A piece of Krell metal is cool to the touch, even after a blaster pistol has fired several shots at it. Compared to water, Krell metal has a heat capacity which is very, very

- A: small
- B: large.
- C: nearly the same.





# WHY USE CLICKERS IN UPPER DIVISION?



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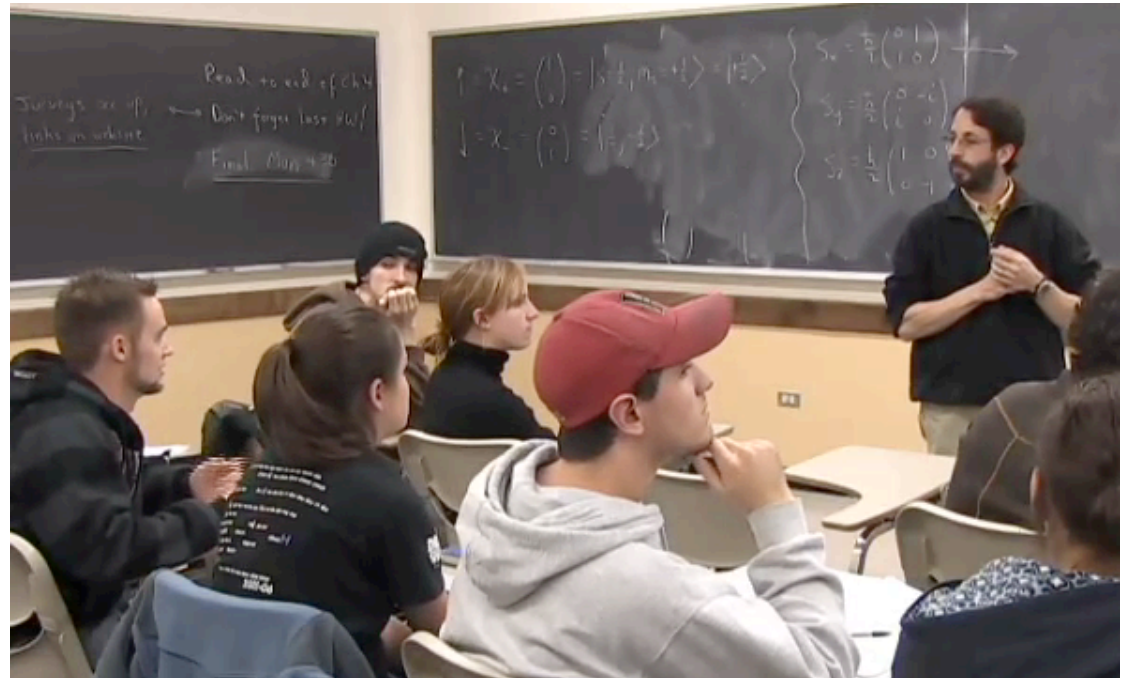
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# What's special about upper-div?

- Faculty and student investment & identity
- Intellectually more sophisticated students
- Complex physics



# Why use clickers in upper-div?

Active engagement and peer instruction is just as useful for juniors as for freshmen



If you have a misconception about some basic physical idea (yes, this does happen at the upper-division), it shows glaringly here. *-student*



# There is a time for telling



... but not too soon\*

\*Dan Schwartz

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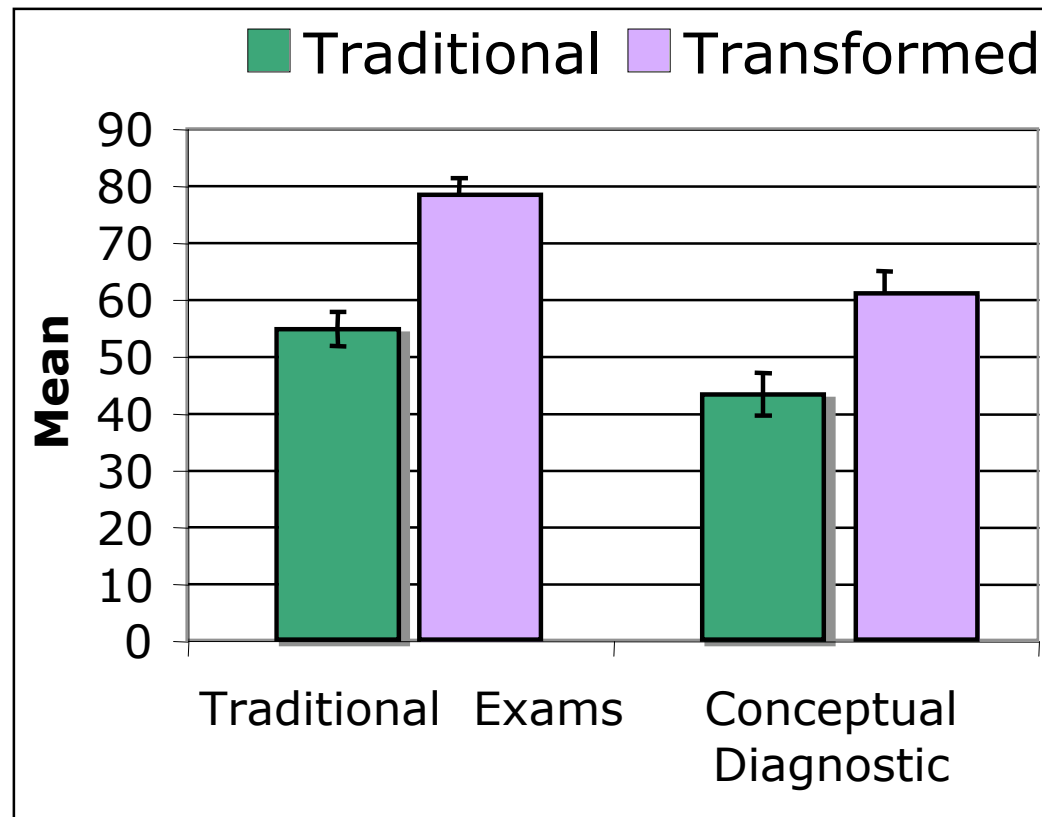
# Arguments *against* upper-div clickers

- Chews up time  
*Ideas are complex*
- Students are sophisticated learners  
*Clickers used to aid learning*
- Discussion easy in small classes  
*Students can still hide & so can misconceptions*
- Students may resist  
*But perhaps only initially...*
- Extra effort for faculty  
*Question banks available if you want to try*



# Students Learn More

- Compare Junior E&M I before/after



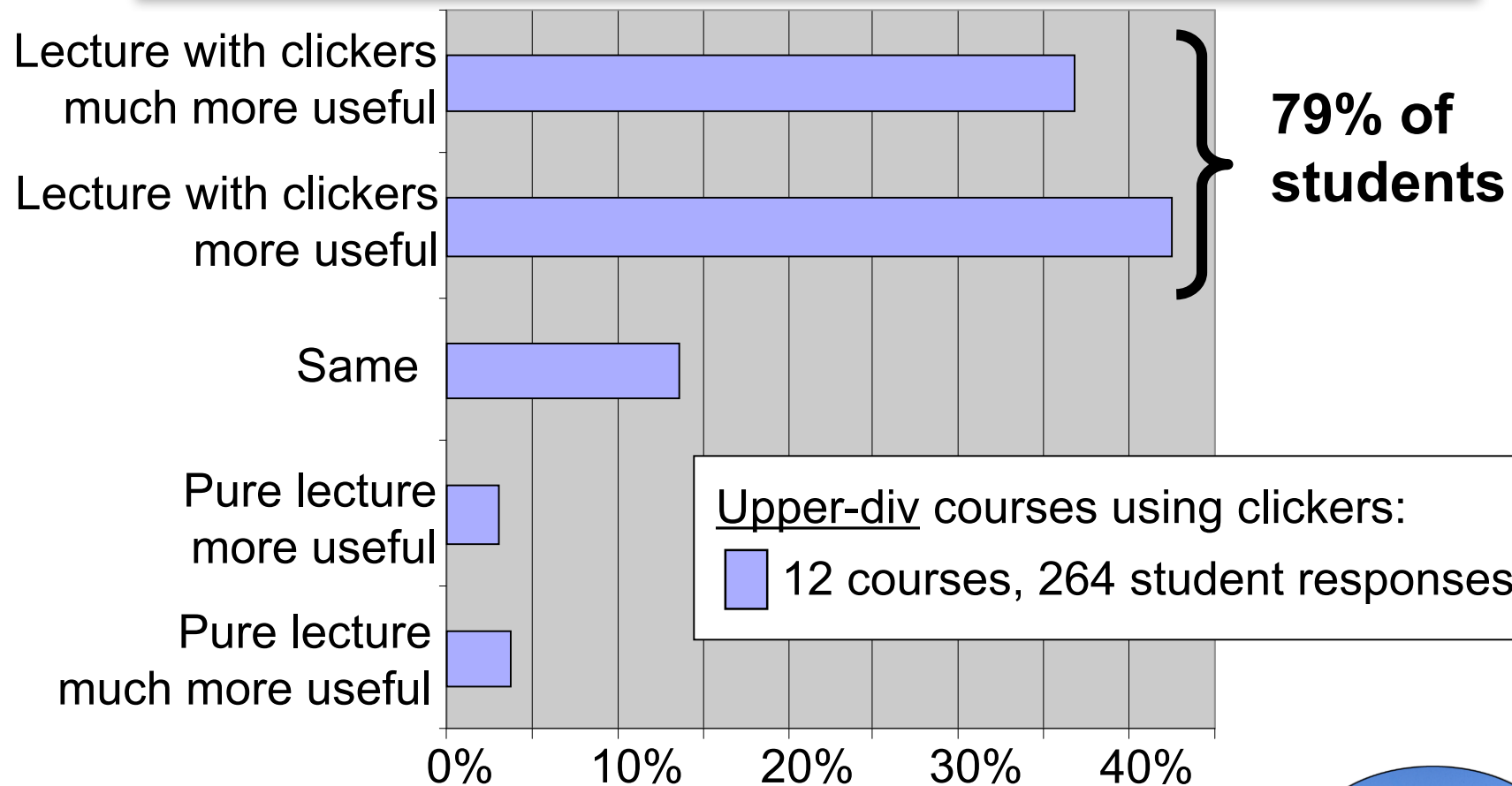
\* Students were similar in pre-course GPA





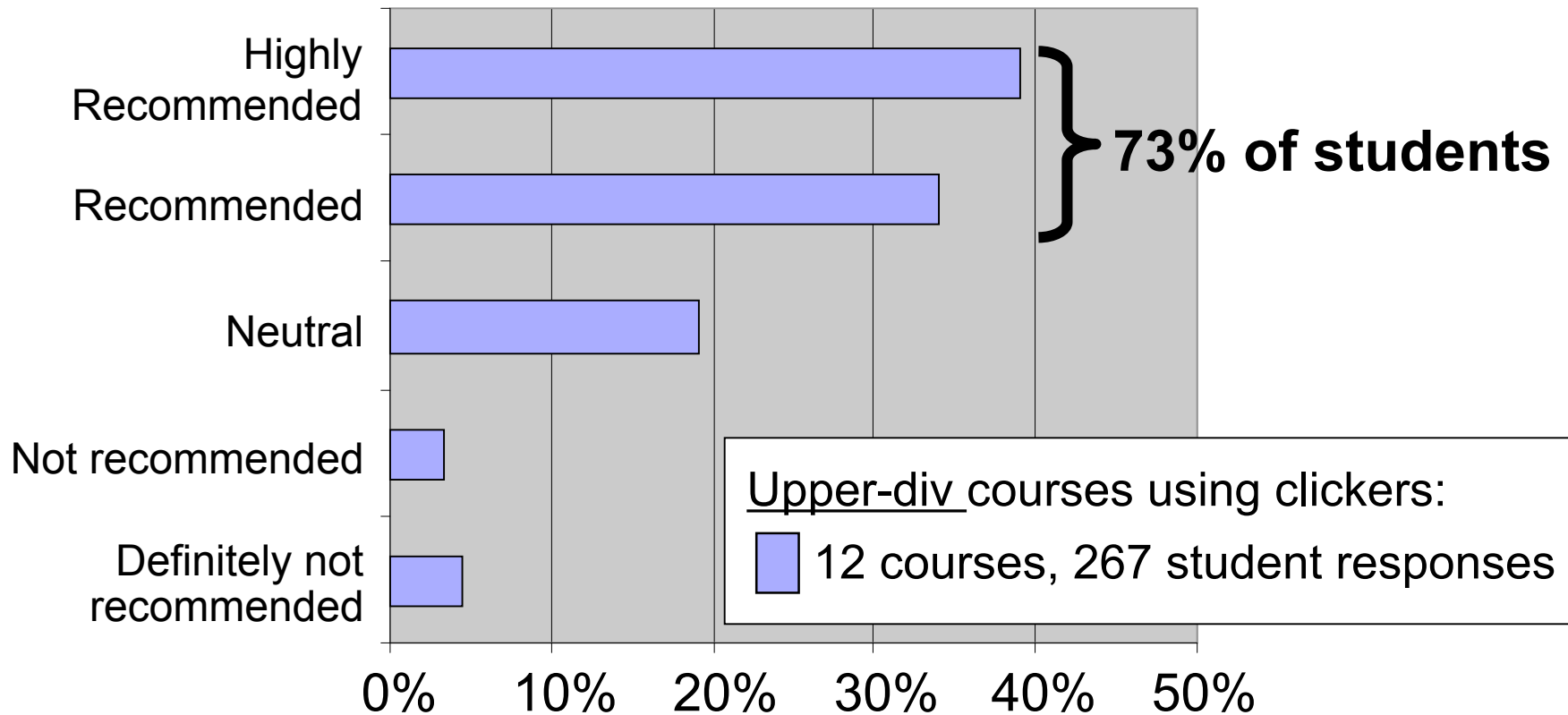
# Students Find Clickers Useful

Q: How useful for your learning is the addition of clicker questions compared to pure lecture with no clicker questions?



# Students Recommend Clickers

Q: Would you recommend using clicker questions in **upper-level** physics courses?



# Quantum Mech Before clickers



Popular lecturer: Oliver DeWolfe  
“Best course I’ve ever taken”  
*Student attitudes towards introducing  
clickers were unfavorable*

I feel that with clicker questions, the class would "feel" more like a lower-division course.

They are quite time consuming, and there is a lot of material to be covered.

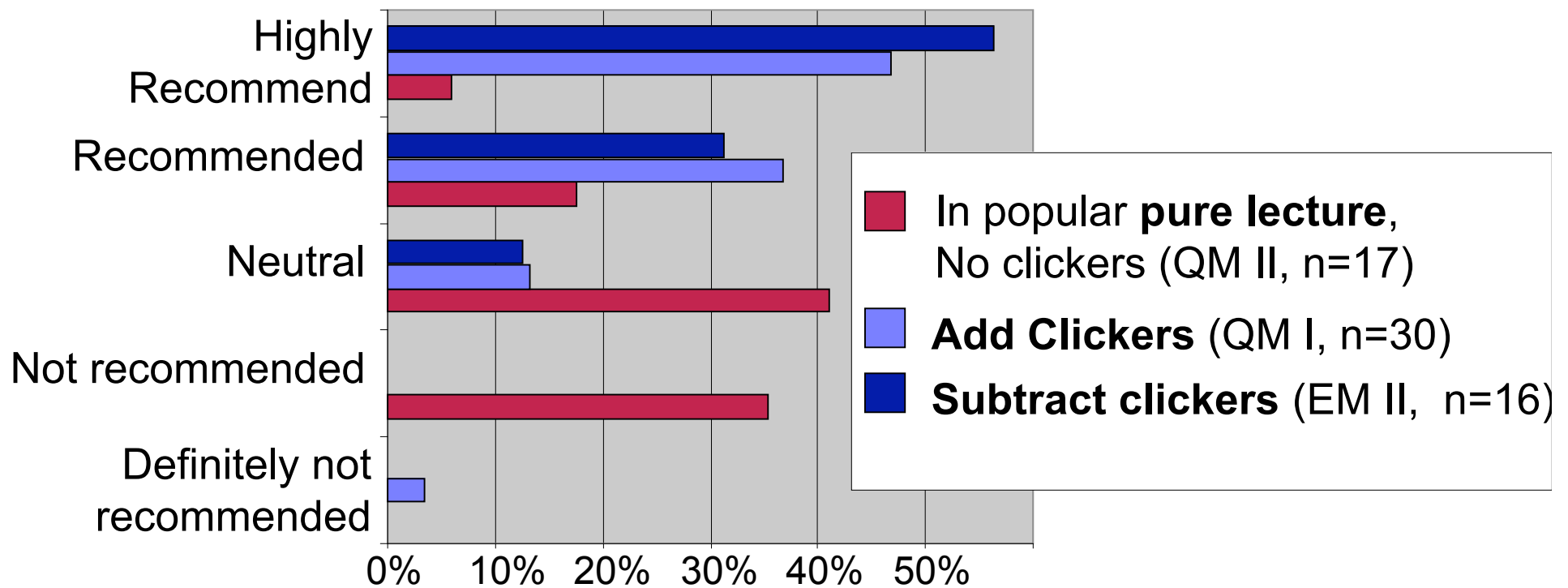
The class is small enough that if you don't understand something you can ask the professor to clarify.

The lecture style was extremely useful **NO CLICKERS!!!**

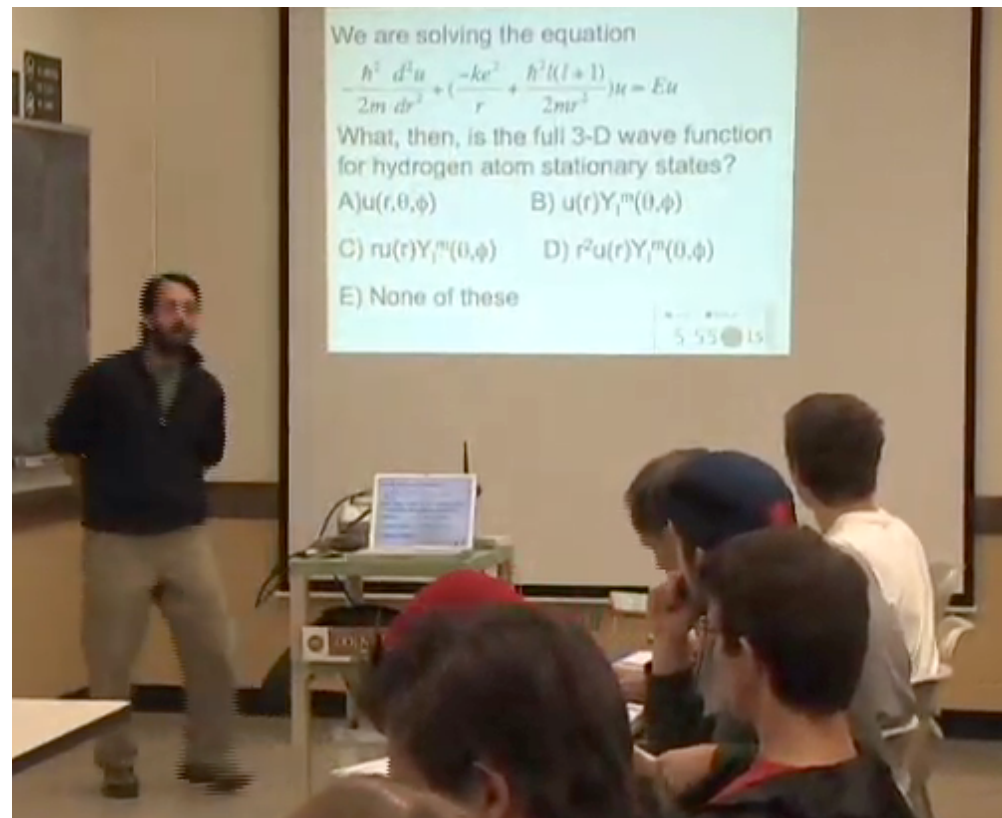


# Students can't predict value

Q: Would you recommend using clicker questions in upper-level physics courses?



# WHAT DOES IT LOOK LIKE?



# What does it look like?

- A range of courses
- Depends on faculty:
  - # of questions per lecture
  - Timing of questions
  - Amount and character of peer discussion
  - Depth of questions





Video: What does upper div clicker question look like?

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# Students' recommendation for implementation

**# of Qs per hour:** 2-5 [2-3 (62%); 4-5+ (21%)]

**Timing:** Interspersed with lecture (87%)

**Peer-discussion:** Allow and encourage (80%)

## **Preferred response mode:**

93% prefer peer discussion as part of response

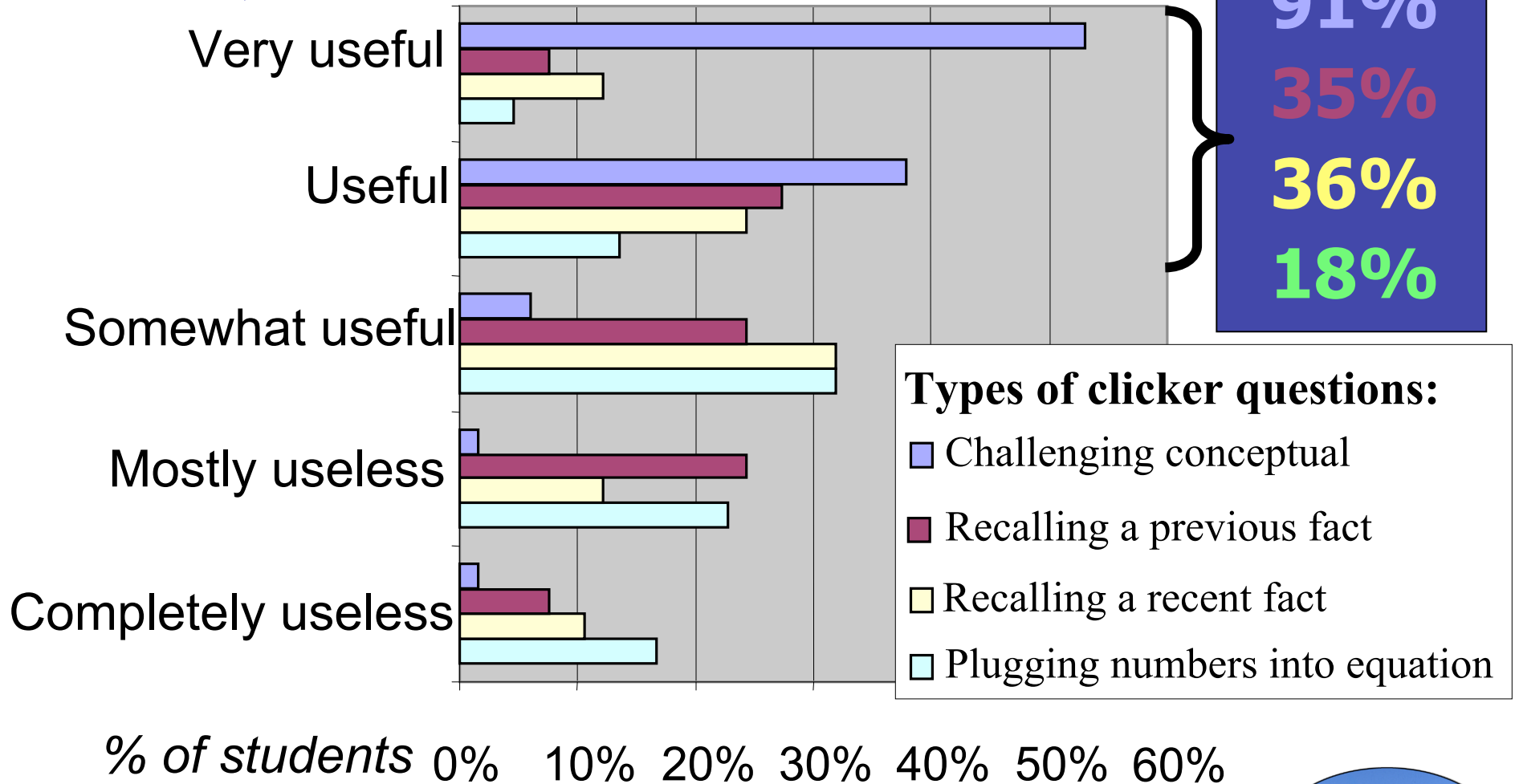
64% prefer some time for individual thinking prior to peer discussion

Upper div courses using clickers  
N=11 courses, 224 responses



# Preferred types of questions

N=4 courses, 66 students *How useful for learning?*



# Tips for Success

- Tell students why you're using clickers
- Ask questions that are challenging (but not too hard)
- Connect questions to lecture
- Create a comfortable environment for discussion
- Don't stress grading of clickers

*Video: Writing questions*



# Video: Writing upper division clicker questions

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# Writing clicker questions

For example:

- Conceptual
- Math/Physics connection
- Application of ideas
- Step in calculation, proof, derivation

*These are similar to lower-division question categories*





# Thank you!

- PER course materials for Quantum and E&M  
<http://www.colorado.edu/sei/departments/physics.htm>

**Handouts at the back!**

- Clicker videos and today's talk at  
**[STEMclickers.colorado.edu](http://STEMclickers.colorado.edu)**

Stephanie.Chasteen@colorado.edu

