Clickers in Upper-Division Courses

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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...

Stephanie V. Chasteen
Clicker Use in Upper-Level Courses
Univ. of Colorado
Breezy Boulder
## Upper-div Clickers at CU

<table>
<thead>
<tr>
<th>Course</th>
<th># times w/clickers</th>
<th>Instructors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical Mechanics</td>
<td>6 (2004-2009)</td>
<td>PER, then non-PER</td>
</tr>
<tr>
<td>E&amp;M I</td>
<td>3 (2008-2009)</td>
<td>PER, then non-PER</td>
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<tr>
<td>E&amp;M II</td>
<td>1 (2009)</td>
<td>Non-PER</td>
</tr>
<tr>
<td>Quantum I</td>
<td>3 (2008-2009)</td>
<td>PER, then non-PER</td>
</tr>
<tr>
<td>Quantum II</td>
<td>1 (2008)</td>
<td>Non-PER</td>
</tr>
<tr>
<td>Graduate AMO</td>
<td>2 (2007, 2009)</td>
<td>Non-PER</td>
</tr>
</tbody>
</table>
Example: Quantum Mech. 1

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

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

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

- Lecture with clickers much more useful: 79% of students
- Lecture with clickers more useful: 12 courses, 264 student responses
- Same: 0%
- Pure lecture more useful: 10%
- Pure lecture much more useful: 10%

Upper-div courses using clickers:
- Lecture with clickers:
  - More useful: 79%
  - Much more useful: 100%
- Pure lecture:
  - More useful: 10%
  - Much more useful: 10%
Students Recommend Clickers

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

- Highly Recommended: 30%
- Recommended: 40%
- Neutral: 20%
- Not recommended: 10%
- Definitely not recommended: 0%

73% of students

Upper-division courses using clickers:
12 courses, 267 student responses
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!!!
Q: Would you recommend using clicker questions in upper-level physics courses?

- **Highly Recommend**
- **Recommended**
- **Neutral**
- **Not recommended**
- **Definitely not recommended**

**In popular pure lecture,**
No clickers (QM II, n=17)

**Add Clickers** (QM I, n=30)

**Subtract clickers** (EM II, n=16)
We are solving the equation
\[ \frac{\hbar^2}{2m} \frac{d^2 \psi}{dr^2} + \frac{-ke^2}{r} \psi + \frac{\hbar^2 (l + 1)}{2mr^2} \psi = E \psi. \]
What, then, is the full 3-D wave function for hydrogen atom stationary states?
A) \( u(r, \theta, \phi) \)  
B) \( u(r) Y_{l,m}(\theta, \phi) \)  
C) \( r u(r) Y_{l,m}(\theta, \phi) \)  
D) \( r^2 u(r) Y_{l,m}(\theta, \phi) \)  
E) None of these
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?
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

Types of clicker questions:
- Challenging conceptual
- Recalling a previous fact
- Recalling a recent fact
- Plugging numbers into equation

% of students

- Very useful
- Useful
- Somewhat useful
- Mostly useless
- Completely useless

How useful for learning?

91%
35%
36%
18%

AAPT Feb 2009
Chilly Chicago

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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
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

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