The *Happy* Marriage of Pedagogy and Technology in the Physics Classroom

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Why use technology?

In support of pedagogical goals

Which pedagogical goals?
Reflecting on Teaching Practice

Transmission/Instructor Centered
- Deliver content to students
- Emphasis on what teacher does/says
- Improvements focus on increasing clarity of transmission

Engagement/Student Centered
- Students actively construct their own understanding of material
- Emphasis on what students learn
- Improvements focus on facilitating active student learning

easy

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Realizing student-centered instruction

Interactive engagement of students in heads-on/hands-on activities which yield immediate feedback through discussion with peers and/or instructors

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Hake, 1998
Technology & interactive engagement—what can technology do?

• Collect and share data (student responses)
• Save data for later review
• Structure interactions
• Feedback/tutoring systems
Clickers or Flashcards: Is There Really a Difference?

N. Lasry, John Abbott College, Montreal Canada, and Harvard School of Engineering & Applied Sciences, Cambridge MA

A growing number of physics teachers are currently turning to instructional technologies such as wireless handheld response systems—colloquially called clickers. Two possible rationales may explain the growing interest in these devices. The first is the presumption that clickers are more effective instructional instruments. The second rationale is somewhat reminiscent of Martin Davis' declaration when purchasing the Oakland Athletics: "As men get older, the toys get more expensive." Although personally motivated by both of these rationales, the effectiveness of clickers over inexpensive low-tech flashcards remains questionable. Thus, the first half of this paper presents findings of a classroom study comparing the differences in student learning between a Peer Instruction group using clickers and a Peer Instruction group using flashcards. Having assessed student learning differences, the second half of the paper describes differences in teaching effectiveness between clickers and flashcards.

About Peer Instruction

Peer Instruction (PI) is a student-centered instructional approach developed at Harvard by Eric Mazur. The method has been welcomed by the science community and adopted by a large number of colleges and universities due, among other reasons, to its common sense approach and its documented effectiveness. A schematic description of the PI method used in this study is shown in Fig. 1.

In PI, the progression of any given class depends on the outcome of real-time student feedback to ConceptTests: multiple-choice conceptual questions. In the early 1990s, students displayed their answer to ConceptTests using a show of hands and later flashcards. Instructors would then count or estimate the number of students holding each alternative conception. Due to the tediousness of counting flashcards in large enrolment courses, flashcards were replaced with wired classroom communication systems and later with wireless clickers.

Study Description

First-semester students in a two-year Canadian public community college were randomly assigned by the registrar to one of two sections of an algebra-based mechanics course. Instruction in the first section consisted of PI with clickers ($n=41$) while the other ConceptTests Students Vote

Correct ans <30% → Revisit Concept

Correct ans: 30%-80% → Peer discussion (2-3 min) students try to convince each other

Correct ans >80% → Remaining misconception explained

Students revote → Next Topic

Brief lecture (=10min) → ConceptTests Students Vote

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Mazur, Peer Instruction (1997)
What do we do with clickers?

Technology ≠ pedagogy

![Diagram showing the Peer Instruction Implementation Algorithm](image)

- **Brief lecture (≈10min)**
- **ConcepTest Students Vote**
  - correct ans <30%
  - correct ans: 30%-80%
  - correct ans >80%
- **Revisit Concept**
- **Peer discussion (2-3min)** students try to convince each other
- Remaining misconception explained
- Students re-vote
- Next Topic

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Beaty & Gerace 2009; Lasry, 2008;
In-class questions w/ clickers

Instructor on in-class questions with clickers:

“Sometimes you get these incredible surprises on things you always thought were very trivial, and simple... clickers helped me understand how little the students are getting from lectures”

“I found it incredibly useful as feedback for me, because [if students didn’t understand] I could address it... right then”
Tools & pedagogy... is that it?

- Norms
  - sense making
  - responsibility for generating ideas
  - responsibility for evaluating ideas
- Instructor actions, grading practices lead to norms, perceived by students
- Classrooms/instructors have variation in norms and practices
- Implications for feedback and how it is used
Technology & interactive engagement—what can technology do?

• Collect and share data (student responses)
• Save data for later review
• Structure interactions
• Feedback/tutoring systems
A whiteboard-intensive physics class

• 1st semester calc-based physics for bio students
• Discussion/lab format, two 3-hour sessions per week
• Students
  – work in small groups responding to a series of prompts,
  – record their work on whiteboards,
  – Present work to peers in whole class discussion facilitated by the instructor
• Limited lecture
A student-centered classroom

Evidence of student thinking:

- On whiteboards, in small group & whole class discussions
- Available to peers and instructor

Feedback:

- Students give/receive peer feedback in small groups, whole class discussions
- Instructor facilitates group work and whole class discussions

Students’ revising thinking

- Students work together to prepare solution
- Students present to whole class – wrong or right – forces instructor to discuss it and come to some sort of resolution

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Whiteboards provide good collaborative space, but are volatile and fixed in size.
Tablets as digital whiteboards

- Student groups use Tablet PCs and Ubiquitous Presenter; work on slides prepared by the instructor
- Student slides can be projected for whole class discussion and are archived on the web
Tablets / digital ink

Suited to

Visual or symbolic material
Informal setting
Limited prep time

Internet and software allow
Sharing
Archiving

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Projecting student work during whole class discussion
Whole class: Student presentations

End of semester survey of students

Which mode was most useful, in general, for viewing other students’ presentations?

Which tool best facilitated referring to your solution while presenting to the class?

Which tool best facilitated modifying your solution while presenting to the class?
Archiving student work

Students found online archive very useful, many page views, including student solutions
We had lots of ideas for how to use this to close the loop, but...
Tablets and collaboration
What we tried next
Digital photographs and Flickr.com

Whiteboards + archiving

- Cameras w/ wireless-enabled SD cards
- Course-specific Flickr account
- Images can be organized
- Tags and comments

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Price, 2011
As with tablets, student found online archive very useful, similar usage patterns, emphasis on student work.
Feedback and revising thinking

Before Flickr was used,
  – Whiteboards were seldom edited after the class discussions.
  – Whiteboards would be erased when the class moved on to a new topic.
  – Tablets were edited during presentation (subset of all work)

In the early stages of archiving,
  – The instructor made comments on Flickr,
  – Students did not edit whiteboards before photos were taken.

Later in the semester,
  – Students began to edit whiteboards in class
  – The photo now captured an edited solution
“Closing the loop”

- Photographing whiteboards motivated a final round of instructor feedback and student revision.
- Unintended and unexpected
- Arose from student interest
Technology in support of interactive engagement

When 24 hours a day aren’t enough...
work nights
Screencasting

http://www.screencast.com/t/78eOpl3G48mG
Implementation

• Tablet PC, iPad, or webcam w/ Screencast.com, screencast-o-matic, Educreations
• Quick and dirty is good enough
• 1 step publishing is a plus
Summary

Technology can support us in the classroom... but should be guided by pedagogical goals