Complex interactions between formative assessment, technology, and classroom practices

Edward Price

eprice@csusm.edu

Department of Physics

California State University
SAN MARCOS

AAPT/PERC Bridging Session
August 4, 20100

Acknowledgements

Chuck De Leone, CSUSM Physics

Katherine Brown, Noah Finkelstein, Robin Marion, Beth Simon, Stephen Tsui, Clarisa Bercovich, Alicia Hart, Lydia Saucedo, John Saunders

CSUSM IITS

Ubiquitous Presenter Development Team

Hewlett Packard Technology for Teaching

Microsoft External Research

Outline

- Formative assessment
- Classroom technology/tools
- Thinking about the classroom's complexity
- Applications/examples

Formative assessment

- Assessments that provide information to students and teachers that is used to improve teaching and learning. (NRC, 2001)
- Activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify… teaching and learning activities (Black & Wiliam, 1998)

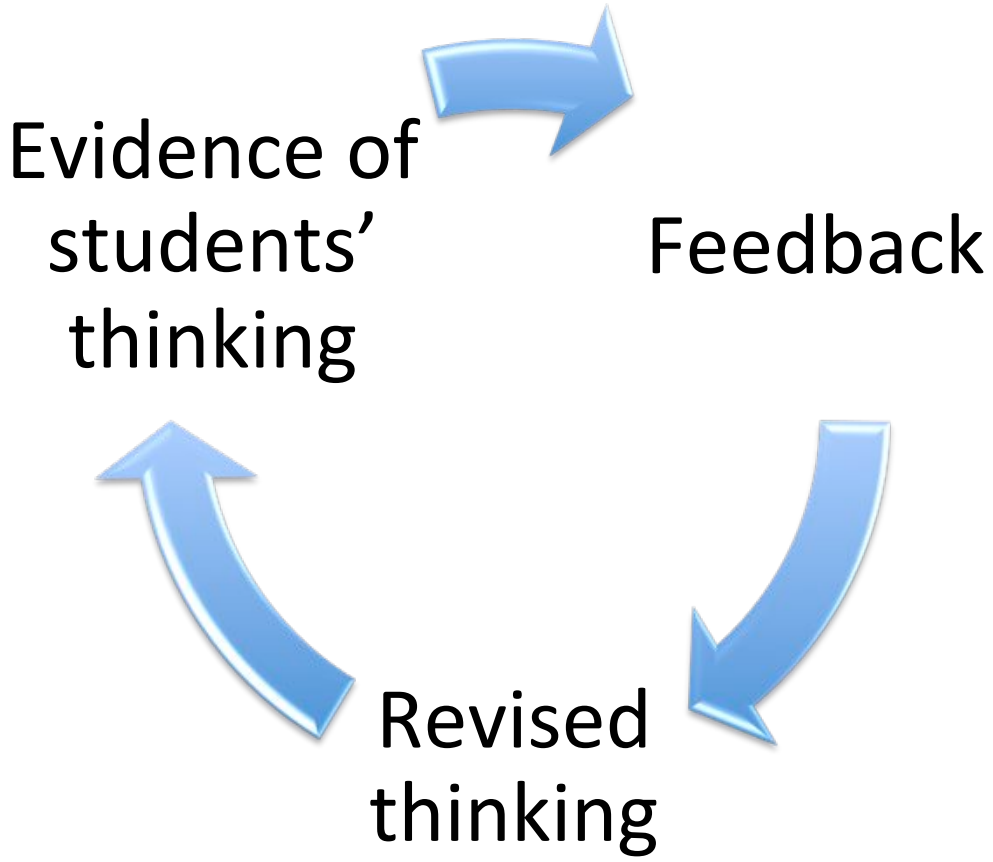
Formative assessment:

Activities providing information used as feedback to modify teaching and learning activities

- Information = evidence of student thinking
- Feedback is essential component
  - To both students and instructor
  - Can come from instructor or peers
  - Basis for action
  - Affective component (how do students respond?)
- Associated with learning gains
- Often informal and ongoing
- Importance of PCK
- Contrast with summative assessment
  - Intended to measure the results of learning

Black & Wiliam, 1998; Bransford, et al., 1999; NRC, 2001; Sadler, 1989

Formative assessment



Black & Wiliam, 1998; Bransford, et al., 1999; NRC, 2001; Sadler, 1989

A natural match

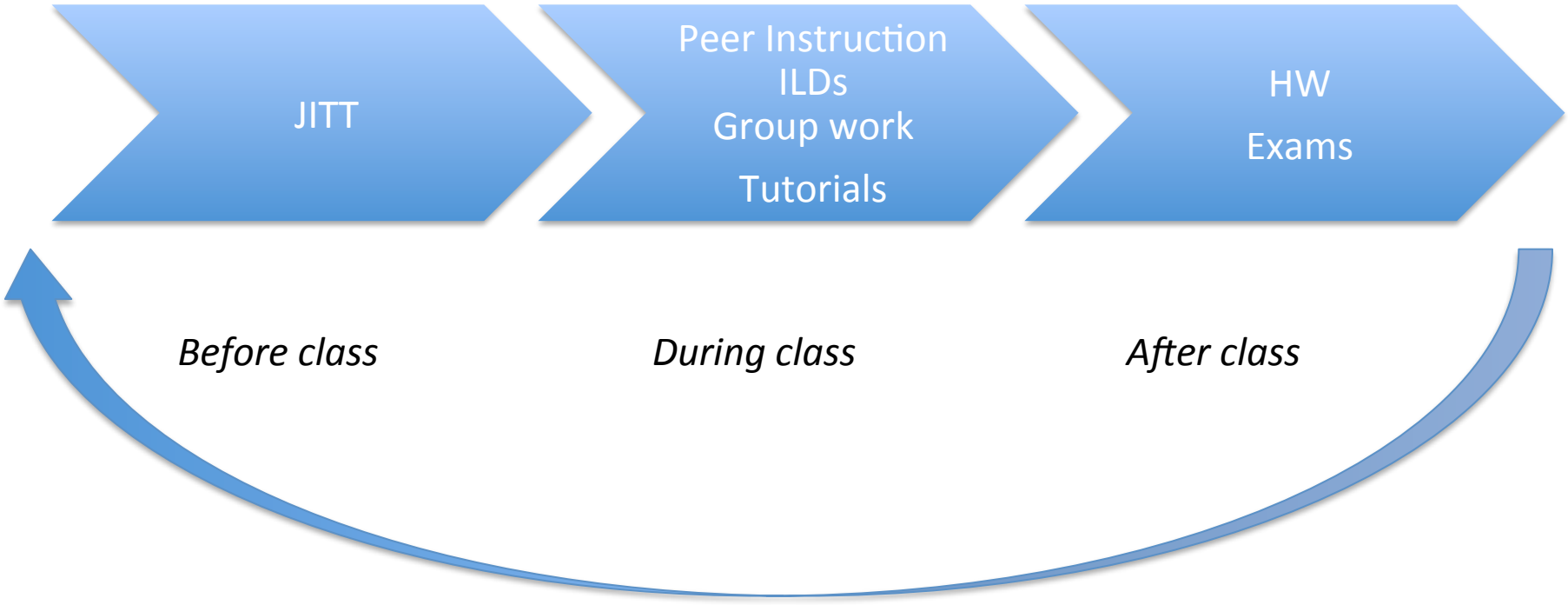
Interactive Engagement

Interactive engagement of students in heads-on/hands-on activities which yield immediate feedback through discussion with peers and/or instructors (Hake, 1998)

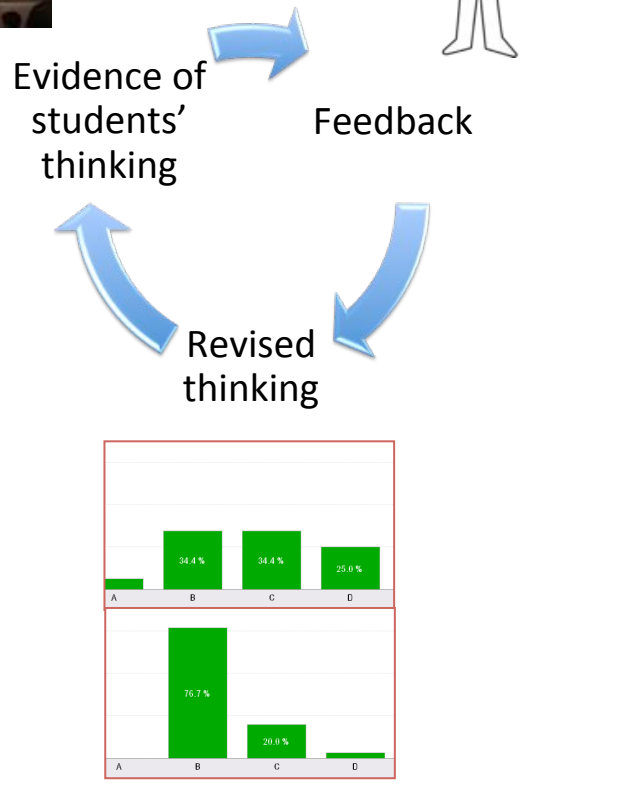
Formative Assessment

Assessments that provide information to students and teachers that is used to improve teaching & learning. (NRC, 2001)

Formative assessment in physics



In-class questions w/ clickers



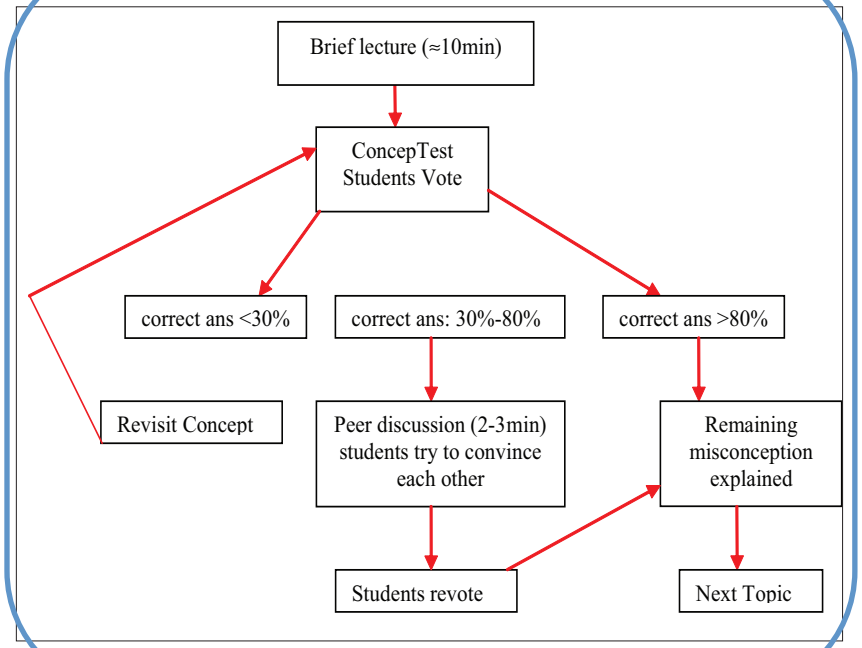
Instructor on in-class questions with clickers:

"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"

What do we do with clickers?

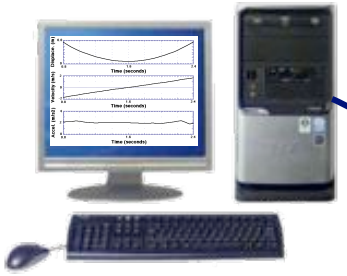
Technology ≠ pedagogy

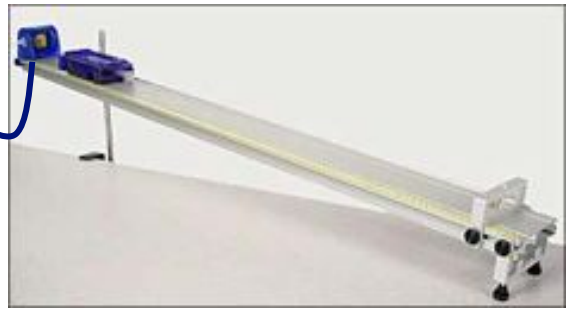


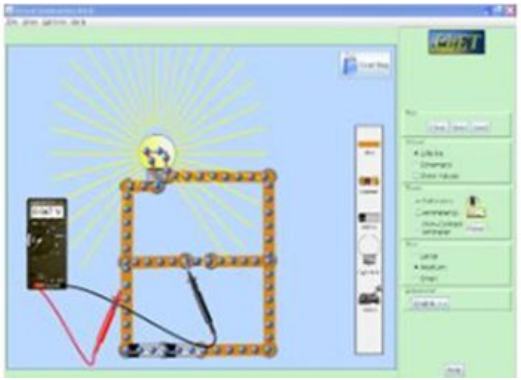
Beaty & Gerace 2009; Lasry, 2008;

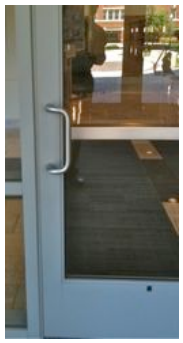
Thinking about tools

- Affordances
- Constraints
- Tools *shape* what we do
- Enable new possibilities
- Not deterministic









Finkelstein, et al., 2005; Lasry, 2008; Norman, 1988; Thornton & Sokoloff, 1990

Clickers vs how we use them

Clickers as a tool

- Fast, easy, private
- Limited answer choices
- Response from all students
- Formalize participation
- Automate sharing
- Provide referent for discussion
- Save data for review, grading, research

Pedagogies featuring class response

- Reading quizzes
- In class conceptual questions
- Peer Instruction (Mazur)
- Question sequences (Reay)
- Question driven instruction (Beatty)

Beaty & Gerace 2009; Lasry, 2008; Mazur, 1997; Reay, Li, & Bao, 2008

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

James & Willoughby, 2011; Turpen & Finkelstein, 2010

Thinking about the classroom with activity theory

A student learning physics is…

part of a community…	(Other students, instructor)
with rules/norms…	(How do things work here?)
and roles…	(Who does what?)
using tools…	(Both material and ideal)

Cole, 1996; Engeström, 1987; Kaptelinin & Nardi, 2006; Nardi, 1996

So far…

- Formative assessment
- Classroom technology/tools
- Thinking about the classroom's complexity

→ Experiences using technology in the classroom

Prepare to vote…

If you could have an iPad for you and each of your students, would you take and use them?

1. Yes
2. No
3. Not sure

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

Looking for formative assessment

Evidence of student thinking:

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

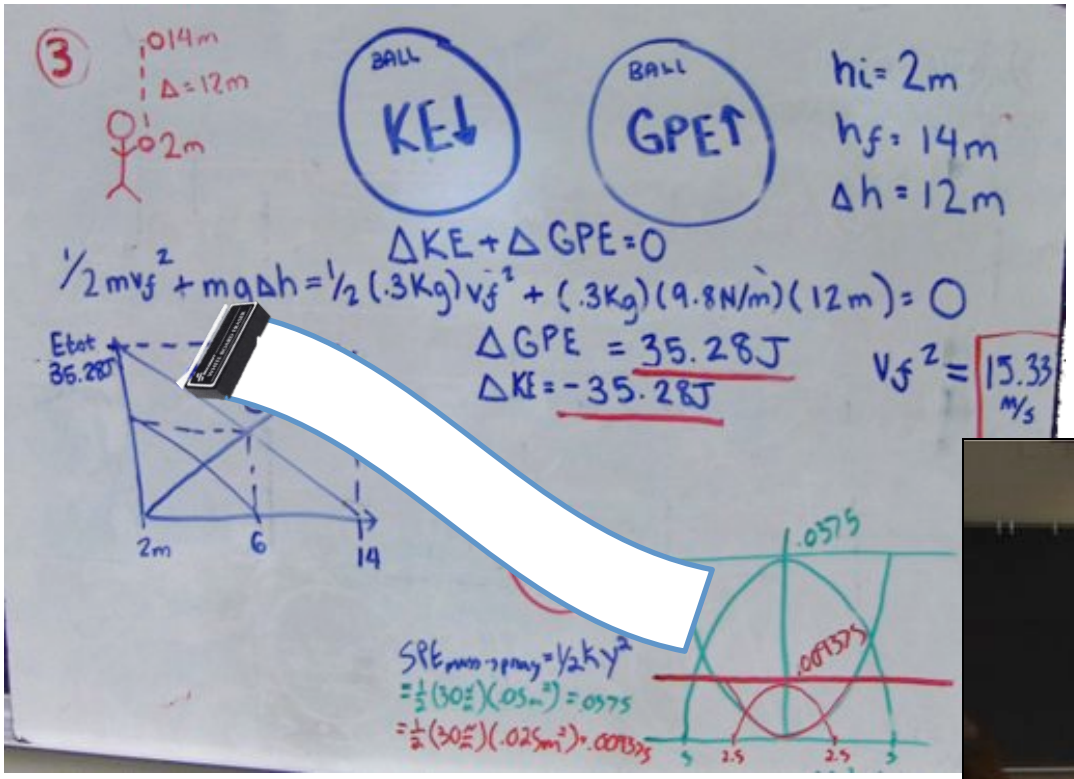
Feedback:

- 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

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

Price & Simon, 2009

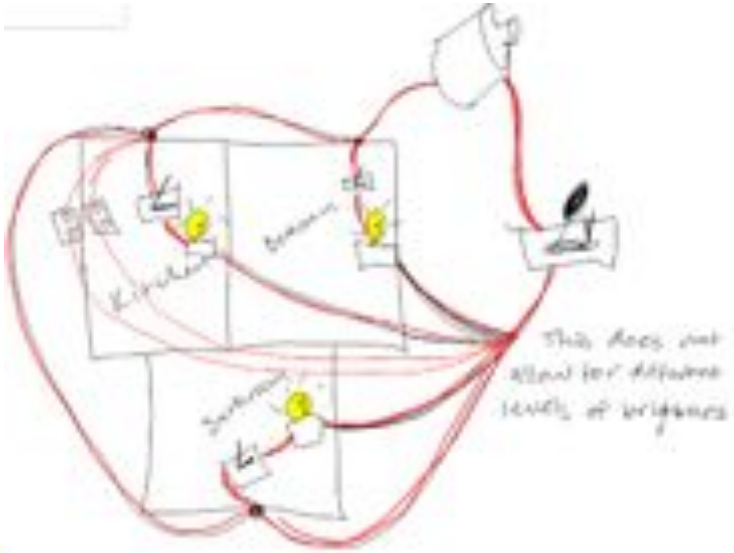
Tablets / digital ink

Suited to

- *Visual or symbolic material*
- *Informal setting*
- *Limited prep time*

Internet and software allow

- *Sharing*
- *Archiving*



$$D_{px} = (V_{fx} - V_{ix})\ m$$

Video showing how Tablets are used in the classroom
http://vimeo.com/9403048

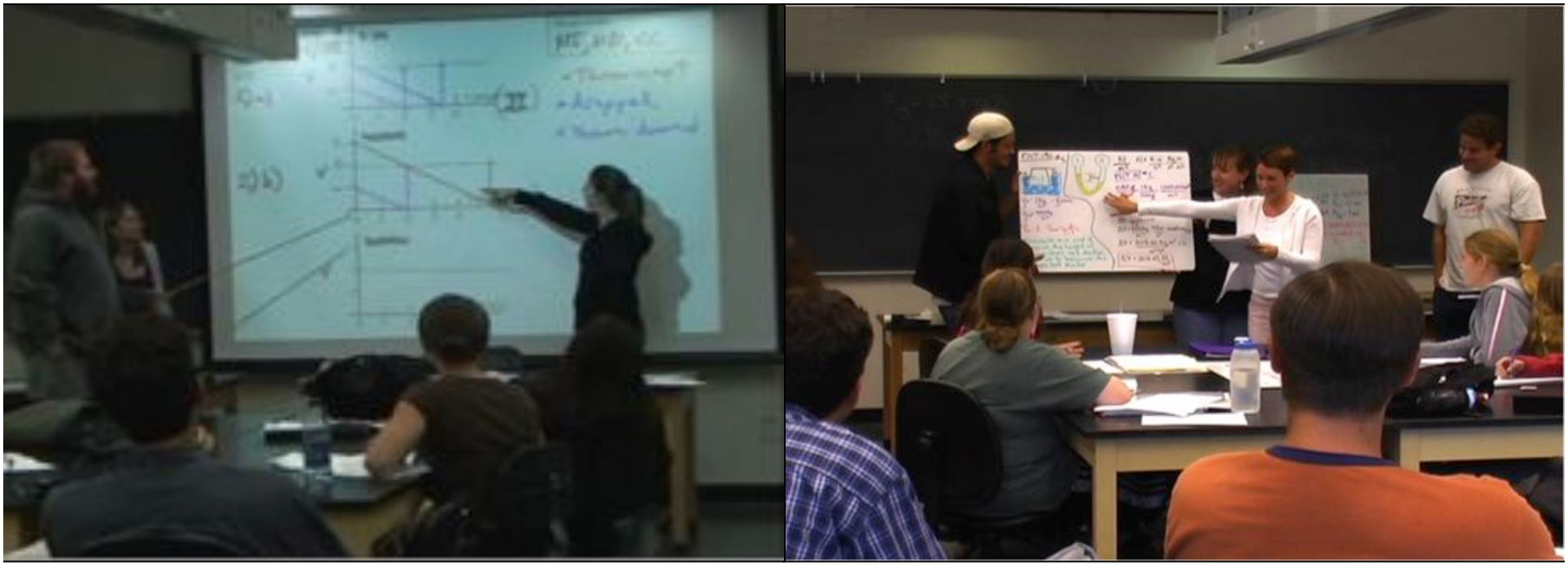
Study design

Two course sections alternate tools in a quasi-experimental design.

- classroom video
- classroom observations
- instructor reflections
- student surveys & interviews
- records of student work

Week	*Section A*	*Section B*
1	Training	Training
2-6	Tablets	Whitebds
7-12	Whitebds	Tablets
13-15	Choice	Choice

Projecting student work during whole class discussion



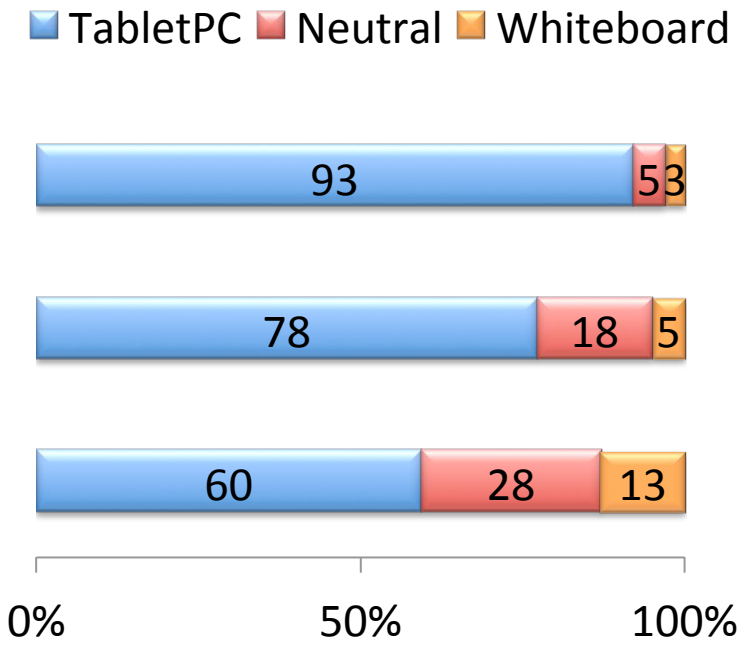
Whole class: Student presentations

End of semester survey of students

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

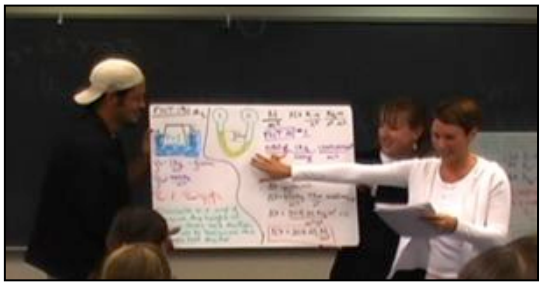
Which tool best facilitated **referring to your solution while presenting to the class**?

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

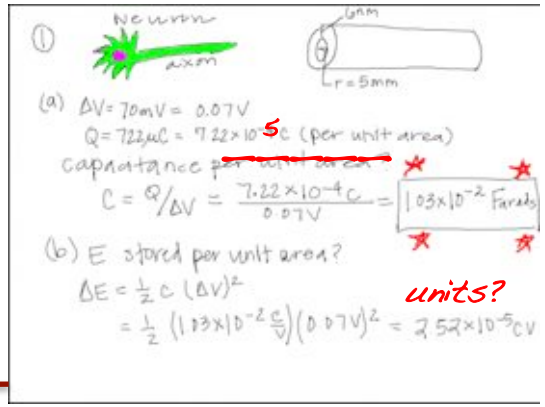


How we got there…

Whiteboards:
Students carry their board to front & present



Tablets:
Instructor tablet controls what's projected
Students present in front of screen
Only instructor tablet can annotate solutions



Initially, instructor marked student work during presentations
→ Shift away from student-led discussion

Later, instructor began handing off pen to students, encouraging them to use his tablet to correct/annotate their work

Ownership of student solutions

Instructor reflections

"[Today] about half of groups used tablet in the front of class to add to their work/or correct their work. This was interesting and nice (I handed pen off to each – ownership!)"

"The student modifications of their own work seems to be going very well. They just use my tablet to ink up their own stuff while presenting."

Understanding the handoff story

Why did things go wrong originally?

- No physical continuity
- Only instructor tablet can make annotation
- Instructor holds onto 'his' tablet

How were things fixed?

- Creation of new norm, mediated by tool, which reorganized roles

Tablets and collaboration

With smaller Tablets

- collaboration became more difficult, though similar distribution of tool use
- instructor monitoring of small group work became harder/more invasive

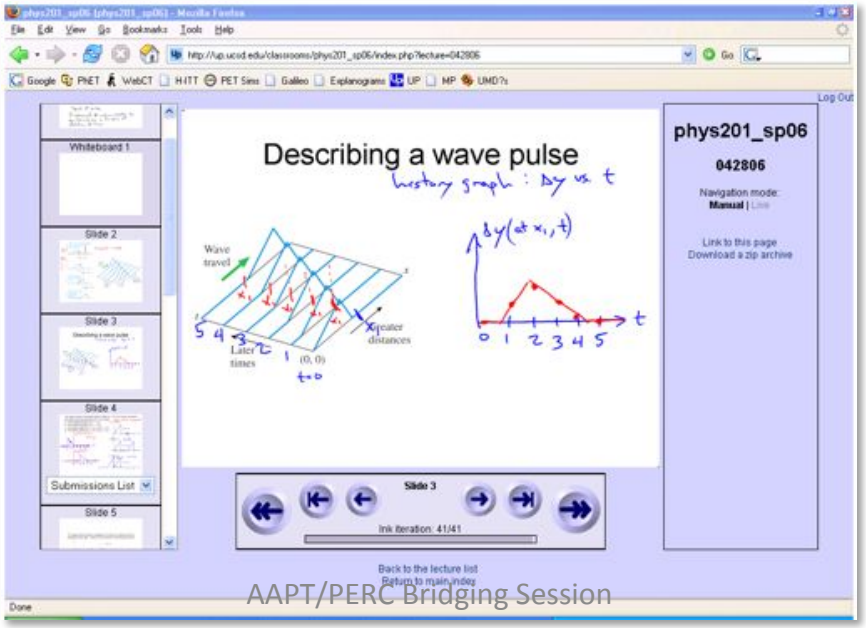
Leading to more instances of

- Of a single student explaining the groups' work to the whole class
- Of groups presenting work that needed substantial fixing during whole class discussion

Archiving student work

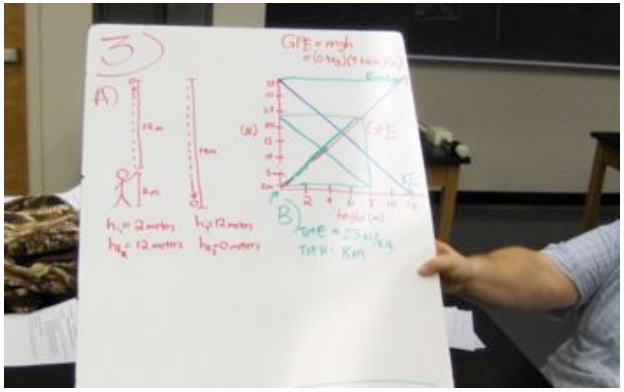
Students found online archive very useful, many page views, including student solutions

We had lots of ideas for how to use this to close the loop, but…



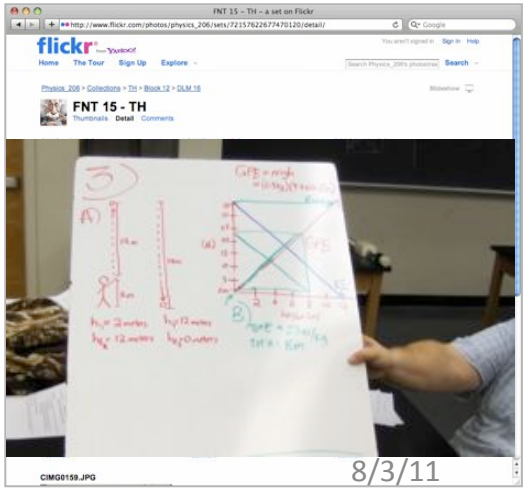
What we tried next

Digital photographs and Flickr.com

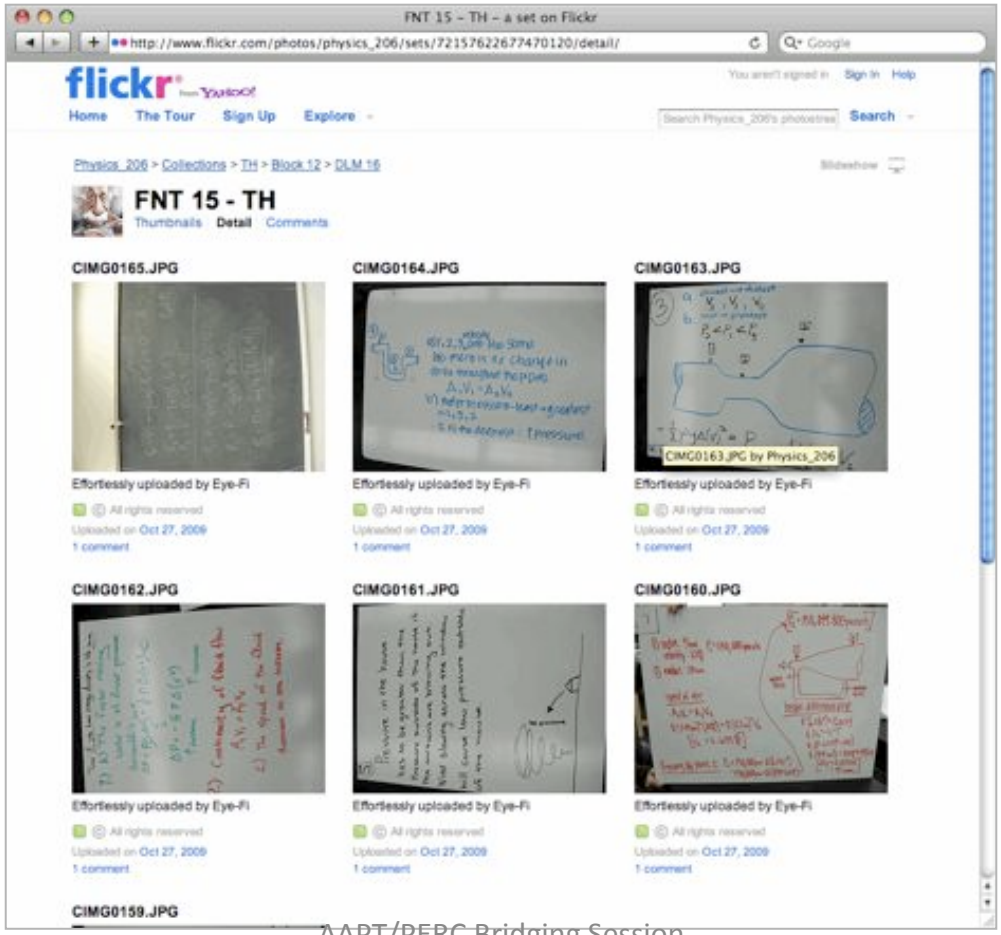


Whiteboards + archiving

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



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, based on role, reorganized by tools - timing, mechanism of capture

Looking for formative assessment

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

	Whiteboard	Tablet	WB & Flickr
Student thinking evident to instructor (group work)	+	-	+
Collaboration	+	-	+
Facilitating whole class discussion	-	+ -	-
Student work available for later review	-	+	+
Student revision of work	-	+	+

Summary

- Overlap of formative assessment with IE
- Tools
- Complexity of the classroom
- These ideas help us understand & create conditions for FA and hence promote learning

Broader connections

- Connecting to others' work
- Filling in pre/post picture
- Replication, dissemination
- Understanding, designing, improving tools

References

Atkin, J. Myron; Black, Paul; Coffey, Janet eds. (2001) *Classroom Assessment and the National Science Education Standards,* NRC

Beatty, I.D.; Gerace, W.J.; Leonard, W.J.; & Dufresne, R.J. (2006) Designing effective questions for classroom response system teaching, *AJP* 74:1, 31-39

Beatty, I.D. & Gerace, W.J. (2009) Technology-Enhanced Formative Assessment: A Research-Based Pedagogy for Teaching Science with Classroom Response Technology, *J Sci Educ Technol* 18:146–162

Black, Paul & Wiliam, Dylan (1998) Assessment and Classroom Learning, *Assessment in Education: Principles, Policy & Practice*, 5:1, 7-74

Bransford, J.D.; Brown, A.L. & Cocking, R.R. (1999) *How People Learn: Brain, Mind, Experience, and School* National Academy Press

Cole, M. (1996) *Cultural psychology: A once and future discipline*, Cambridge, MA: Harvard University Press.

Cowie, Bronwen & Bell, Beverley (1999) A Model of Formative Assessment in Science Education, *Assessment in Education: Principles, Policy & Practice*, 6:1, 101-116

Engeström, Y. (1987) *Learning by Expanding: An Activity-Theoretical Approach to Developmental Research*, Helsinki: Orienta-Konsultit.

Fakcharoenphol, W., Potter, E. & Stelzer, T. (2011) What students learn when studying physics practice exam problems, *PRST-PER*, 7, 010107

Harlen, Wynne (1999) Purposes and Procedures for Assessing Science Process Skills, *Assessment in Education: Principles, Policy & Practice*, 6:1, 129-14

Henderson, C. & Harper, K. (2009) Quiz Corrections: Improving Learning by Encouraging Students to Reflect on Their Mistakes, *TPT* 47:9, 581-586

Kaptelinin, V., Nardi, B. A. (2006) *Acting with Technology: Activity Theory and Interaction Design*, Cambridge: MIT Press.

Lasry, N. (2008) Clickers or Flashcards: Is There Really a Difference? *The Physics Teacher* **46,** 242-244

Mason, A. & Singh, C. (2010) Do advanced physics students learn from their mistakes without explicit intervention?, *Am. J. Phys*. 78:7, 760-767

Nardi, B. A. (1996) *Context and Consciousness: Activity Theory and Human-computer Interaction*, Cambridge, MA: MIT Press.

Norman (1988) *The Psychology of Everyday Things,* New York: Basic Books.

Otero, Valerie & Nathan, Mitchell (2008) Preservice Elementary Teachers' Views of Their Students' Prior Knowledge of Science, *JRST*, 45:4, 497–523

Price, E. & Simon, B. (2009) Ubiquitous Presenter: A Tablet PC-based system to support instructors and students in the classroom, *TPT*, **47** 570

Price, E. et al. (2011) Don't erase that whiteboard! *TPT,* in press.

Reay NW, Li P, Bao L (2008) Testing a new voting machine question methodology. *Am J Phys* 76(2):171–178

Sadler, D. Royce (1998) Formative assessment: Revisiting the territory, *Assessment in Education*, 5:1, 77-84

Sadler, D. Royce (1989) Formative assessment and the design of instructional systems, *Instructional Science* 18, 119-144

Turpen, C. & Finkelstein, N.D. (2010) The construction of different classroom norms during Peer Instruction: Students perceive differences, *PRST-PER* 6, 020123