Thinking broadly about educational technology

Edward Price

eprice@csusm.edu

California State University
SAN MARCOS

Department of Physics

Acknowledgements

Noah Finkelstein, Fred Goldberg,
Steve Robinson, Beth Simon

Charles De Leone, Stephen Tsui,
Clarisa Bercovich, Robin Marion
Chase Keene, Kornel Czarnocki, Alicia Hart,
Lydia Saucedo, John Saunders

CSUSM IITS

Hewlett Packard Technology for Teaching
Microsoft External Research


http://www


HAPPY

I believe that the [redacted] is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks.

The education of the future, as I see it, will be conducted through the [redacted]… where it should be possible to obtain 100% efficiency.

[redacted]

Cuban, Larry. *Teachers and Machines: The Classroom Use of Technology Since 1920.*

I believe that the motion picture is destined to revolutionize our educational system and that in a few years it will supplant largely, if not entirely, the use of textbooks.

The education of the future, as I see it, will be conducted through the medium of the motion picture… where it should be possible to obtain 100% efficiency.

Thomas Edison, 1922

Cuban, Larry. *Teachers and Machines: The Classroom Use of Technology Since 1920.*

Typical classroom- today

Earliest known example of a school-room from Sumer, circa 3000 BC

Will computers 'fix' education?

What do we mean by learning?

Knowledge
Comprehension
Application
Analysis
Synthesis
Evaluation

Problem solving
Communication
Collaboration
Management of complex tasks
Nature of science

- Before thinking about technology specifically, what do we know about teaching/learning?
- What are our goals?

POLICY FORUM

EDUCATION

Scientific Teaching

Jo Handelsman,[1*] Diane Ebert-May,[2] Robert Beichner,[3] Peter Bruns,[4]
Amy Chang,[5] Robert DeHaan,[6,†] Jim Gentile,[7] Sarah Lauffer,[1]
James Stewart,[8] Shirley M. Tilghman,[9] William B. Wood[10]

Since publication of the AAAS 1989 report "Science for all Americans" (*1*), commissions, panels, and working groups have agreed that reform in science education should be founded on "scientific

do scientific teaching, as we do with supporting online material (SOM) (*3*) and table (see page 522). We also present recommendations for moving the revolution forward.

wide range of institutions demonstrated better problem-solving ability, conceptual understanding, and success in subsequent courses compared with students who had learned in traditional, passive formats (*3*).

These results are neither isolated nor discipline-specific. At the University of Oregon, Udovic showed dramatic differences between students taught biology in a traditional lecture and those taught "Workshop Biology," a series of active, inquiry-based learning modules (*6*). Similarly impressive results were achieved by Wright in

Scientific teaching involves active learning strategies to engage students in the process of science and teaching methods that have been systematically tested and shown to reach diverse students

Learning principles

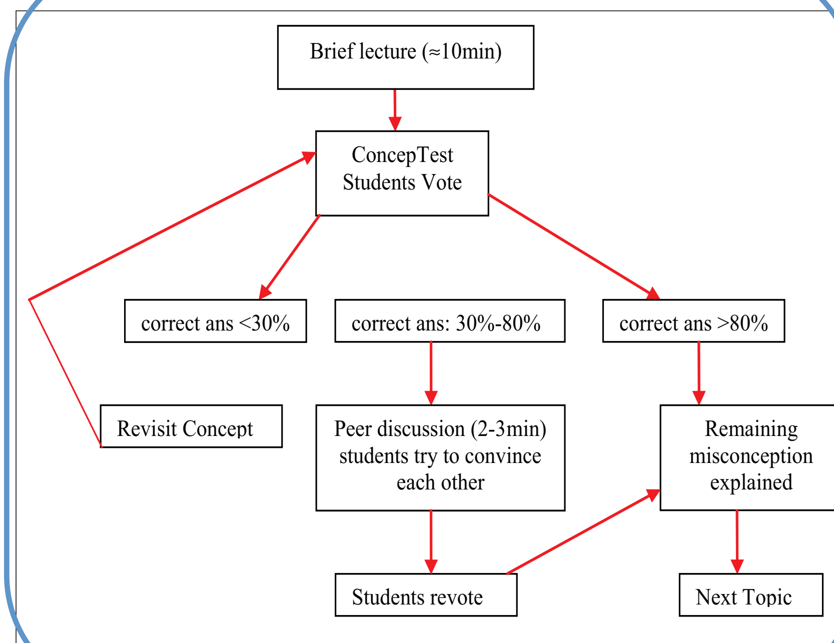
1. Learning builds on prior knowledge
2. Learning is a complex process requiring scaffolding
3. Learning is facilitated through interaction with tools
4. Learning is facilitated through peer interactions
5. Learning is facilitated through establishment of norms and expectations

J. D. Bransford, A. L. Brown, and R. R. Cocking, *How People Learn: Brain, Mind, Experience, and School* (NAP, Washington, D.C., 2000).
E. F. Redish, Implications of Cognitive Studies for Teaching Physics, American Journal of Physics **62**, 796 (1994).
D. Hammer, et al., in *Transfer of Learning: Research and Perspectives*, edited by J. Mestre (Information Age Publishing, 2004).
Y. Engeström, *Learning by Expanding: An Activity-theoretical Approach to Developmental Research* (Orienta-Konsultit Oy, 1987).
M. Cole, *Cultural Psychology: A Once and Future Discipline* (Harvard University Press, Cambridge, MA, 1998).
L. S. Vygotsky, *Thought and Language* (MIT Press, Cambridge, MA, 1986).
E. G. Cohen, *Designing Groupwork: Strategies for the Heterogeneous Classroom* (Teachers College Press, 1994), p. 203.
R. Driver, P. Newton, and J. Osborne, Establishing the Norms of Scientific Argumentation in Classrooms, Science Education **84**, 287-312 (2000).

- Where does technology come in?
- How can we think about how technology gets used and changes the classroom?

What do we do with clickers?

Technology ≠ pedagogy



Mazur, *Peer Instruction* (1997) Beaty & Gerace 2009; Lasry, 2008;

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

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

Clickers vs how we use them

Clickers as a tool

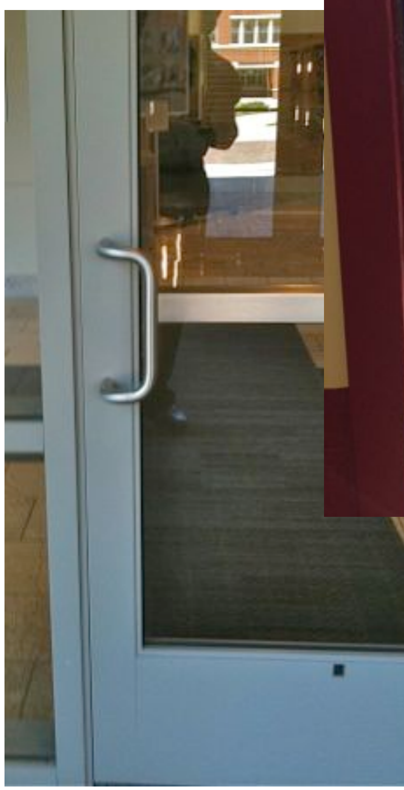
- Fast, easy, private
- Limited answer choices
- Response from all students
- Formalize participation
- Automate sharing
- Provide referent for discussion
- Save data for review, grading, research

Pedagogies featuring class response

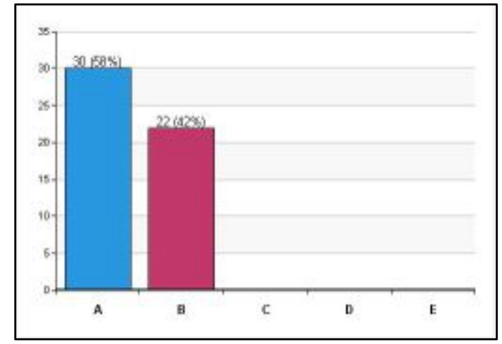
- Reading quizzes
- In class conceptual questions
- Peer Instruction (Mazur)
- Question sequences (Bao)
- Question driven instruction (Beatty)

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

Thinking about tools



Thinking about tools



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

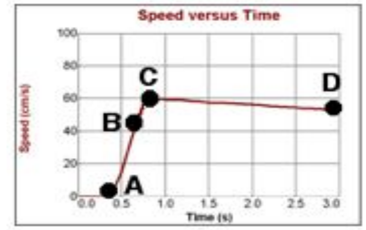
Finkelstein, et al., 2005; Lasry, 2008; Norman, 1988; Thornton & Sokoloff, 1990

Tools & pedagogy… is that it?

- Norms
  - sense making
  - responsibility for generating ideas
  - responsibility for evaluating ideas
- Roles
  - Who does what
- 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

Small Group Discussion



A framework for thinking about the physics classroom

A student learning physics is engaged in an activity as…

part of a community…	(Other students, instructor)
with rules/norms…	(How do things work here?)
and roles…	(Who does what?)
using tools…	("Technology" but also representations, language, etc)
In a broader context	

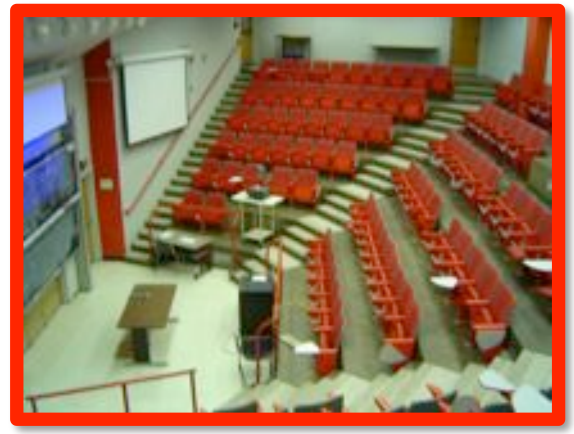
Cole, 1996; Engeström, 1987; Kaptelinin & Nardi, 2006; Nardi, 1996

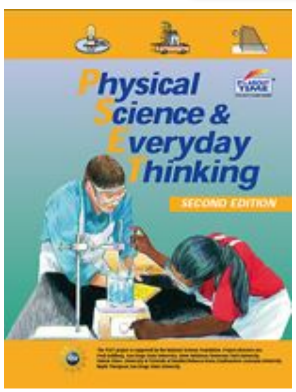
Other examples: MBL, simulations…

- How can these tools further pedagogical goals?
- How do these tools
  - Reorganize who does what?
  - Change participation?
  - Allow new/different norms?
  - Reinforce/support existing norms?

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

Adapting a small, discussion-lab course to large, lecture format

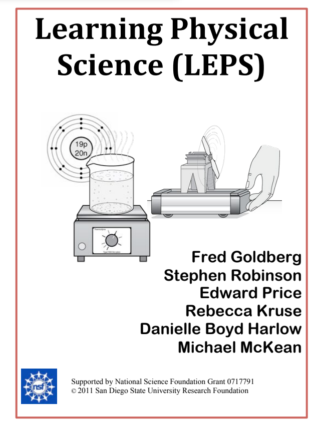




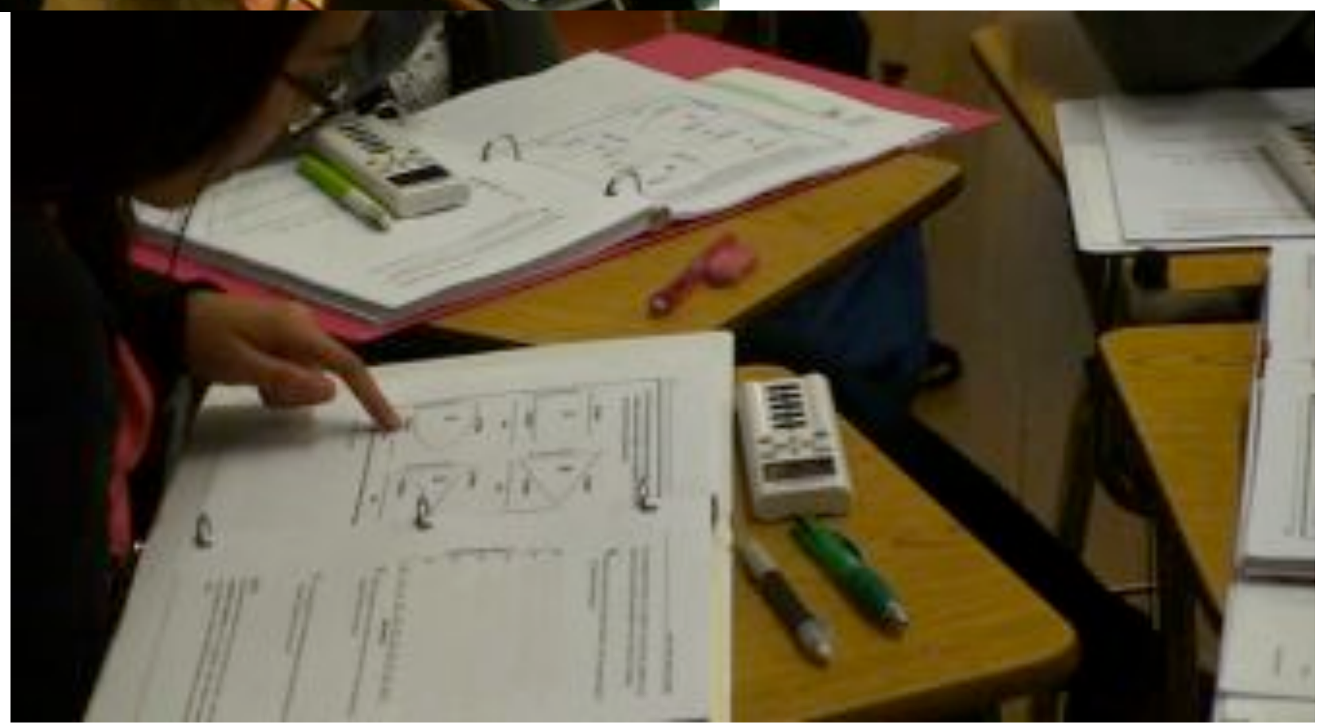
Can we do this?

What does it look like?

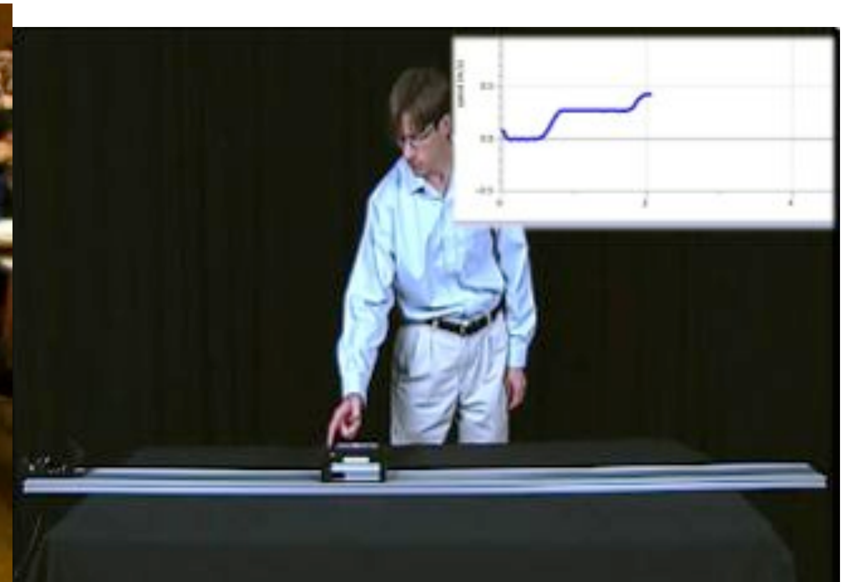
Does it work?



Development supported by NSF ESI-0096856 and DUE-0717791

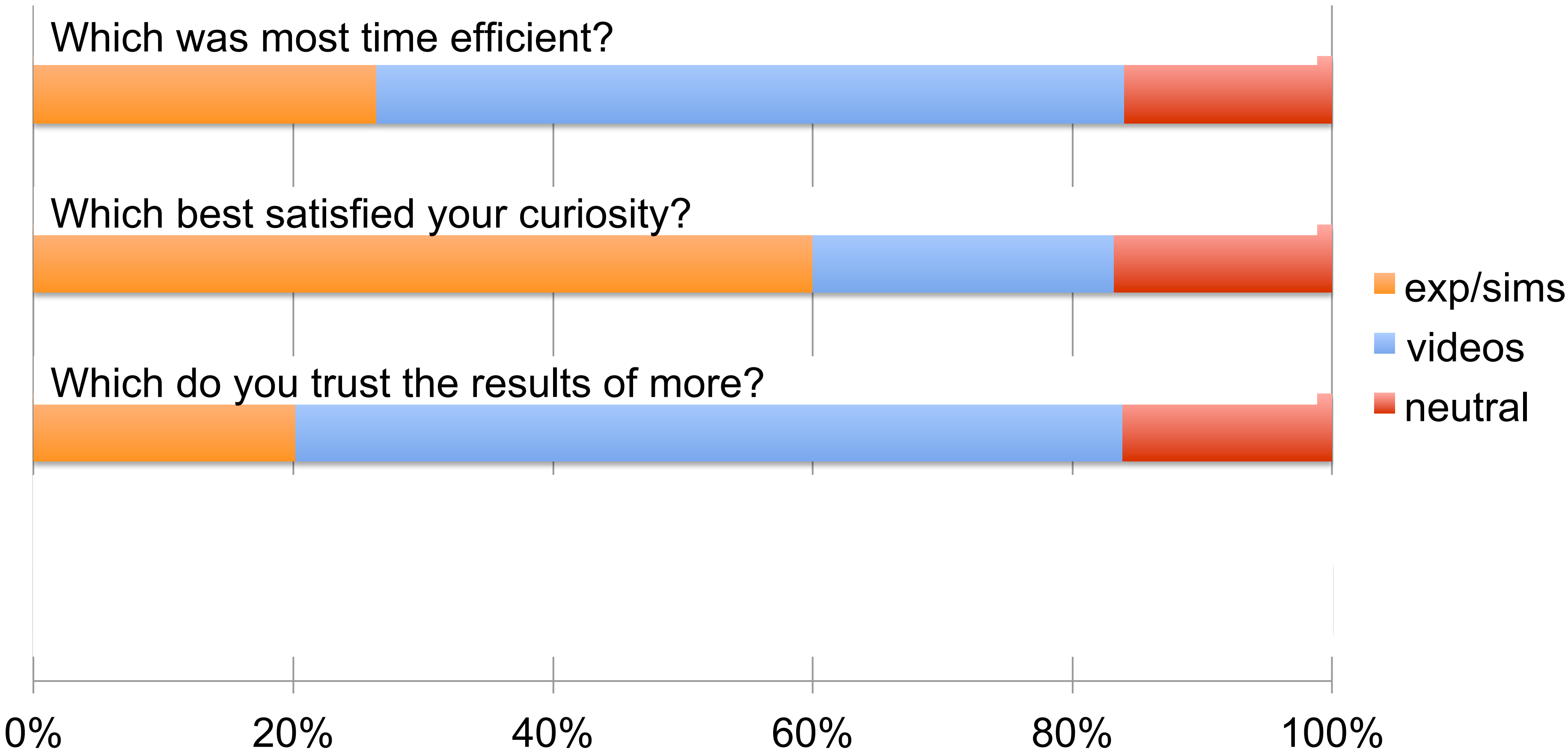


HANDS-ON VS WATCHING



Hands on experiments	Videos of experiments
Some spontaneous experimentation	Only recorded experiment is available
Unintended set ups, methods, observations	Results are clear and unambiguous
Group members have varied roles; group dynamics matter	All students have the same role (watch and interpret)
Different groups sometimes observe different outcomes	All students/groups have access to same observation
Require more time; pacing different for different groups	Require less time; pacing is uniform for entire class

Student perceptions of hands-on vs videos



Rules, Roles, Community, and Context

- Student concern about "correct results" consistent with answer-making orientation, larger context (course, university)
- Hands on experiments have more failure modes – group dynamics, time constraints, unintended observations
- Clicker questions helped establish "consensus" results from hands on experiments; students readily accept these results

Which goals?

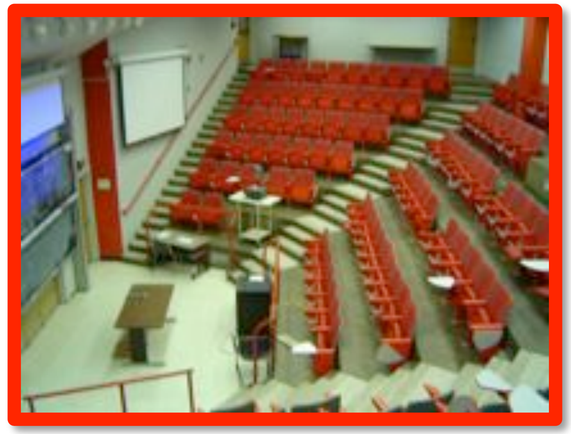
Videos are more time efficient at providing evidence for developing physics concepts;

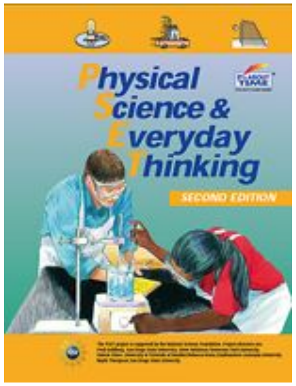
Hands-on activities allow students to engage in science practices, and develop greater judgment and interpretive skills.

→ The choice of how to spend class time represents a choice between goals.

STUDENTS' WRITING OF SCIENTIFIC EXPLANATIONS IN A LARGE CLASS

Adapting a small, discussion-lab course to large, lecture format

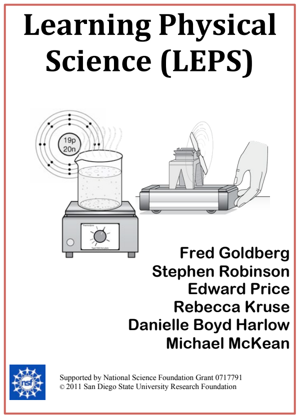




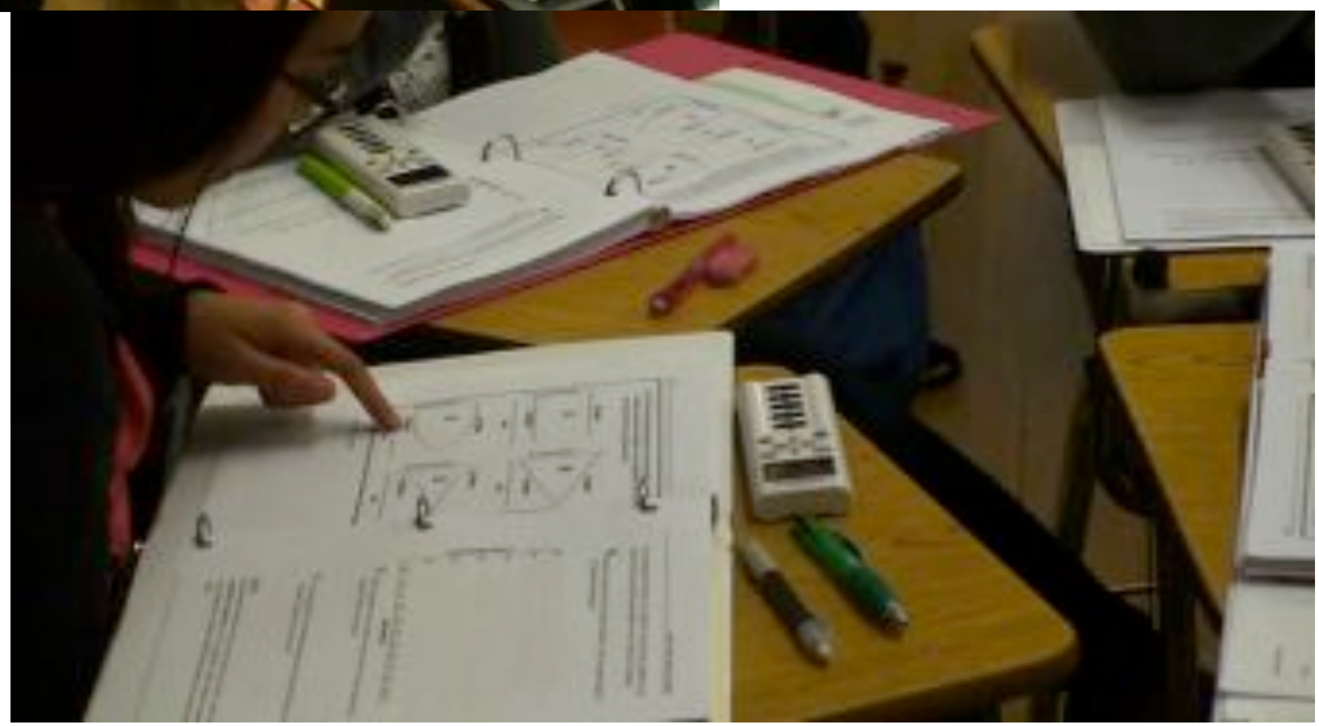
Can we do this?

What does it look like?

Does it work?



Development supported by NSF ESI-0096856 and DUE-0717791



Calibrated Peer Review

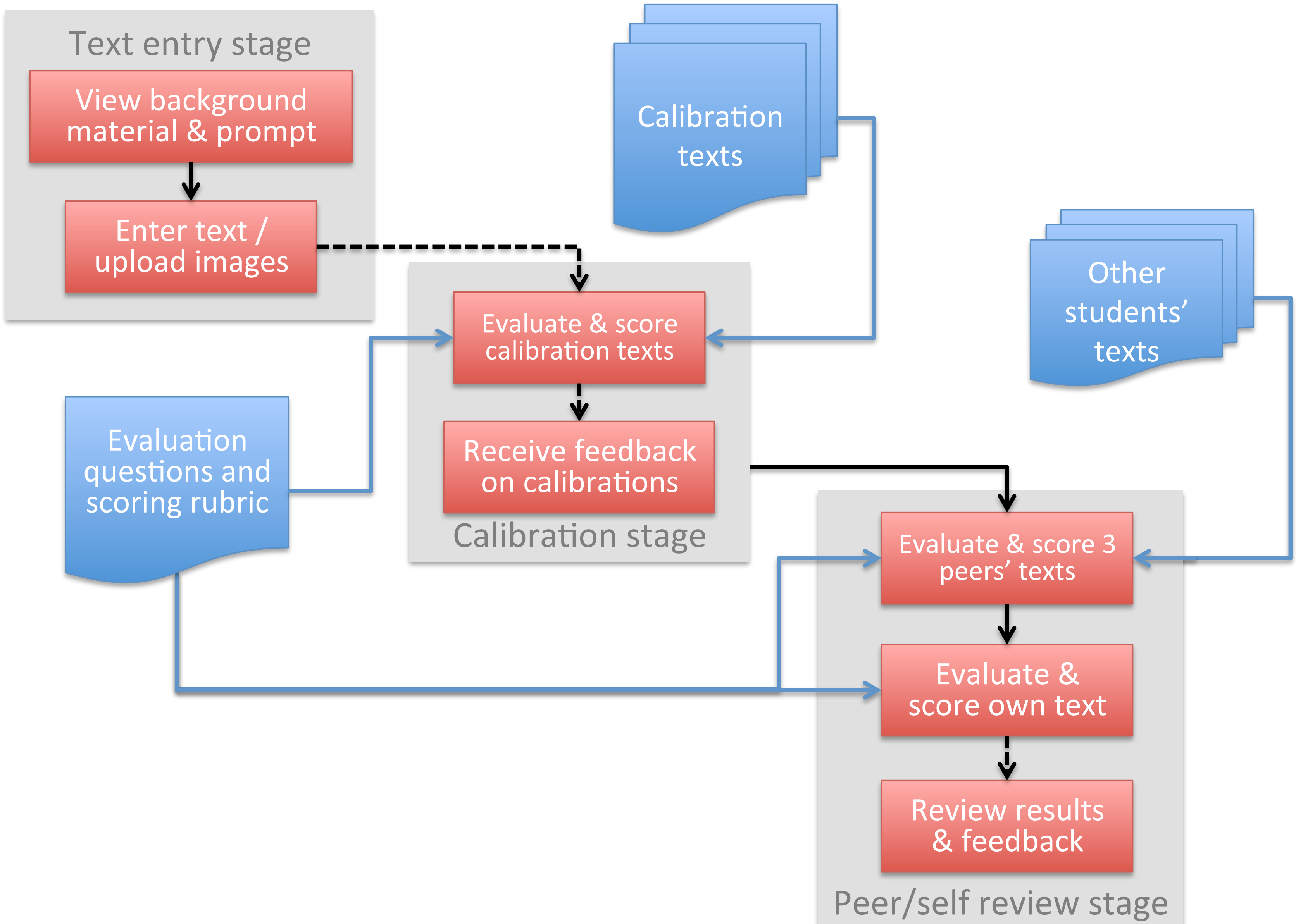
A web-based tool that supports students' construction and evaluation of explanations.

3 stages:

1. Text entry
2. Calibration
3. Peer review

CPR was developed at UCLA http://cpr.molsci.ucla.edu/Home.aspx

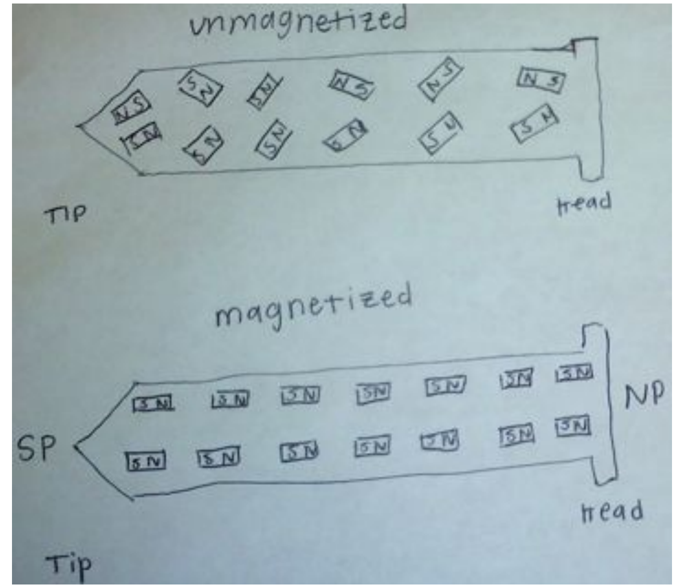
Calibrated Peer Review



Price, Goldberg, et al. 2012

CPR Task Example

Evaluation questions:
“Does the first paragraph correctly describe that within the unmagnetized nail there are (many) tiny magnets that are randomly oriented; that is, their NPs (or SPs) point in different directions, or something similar?”



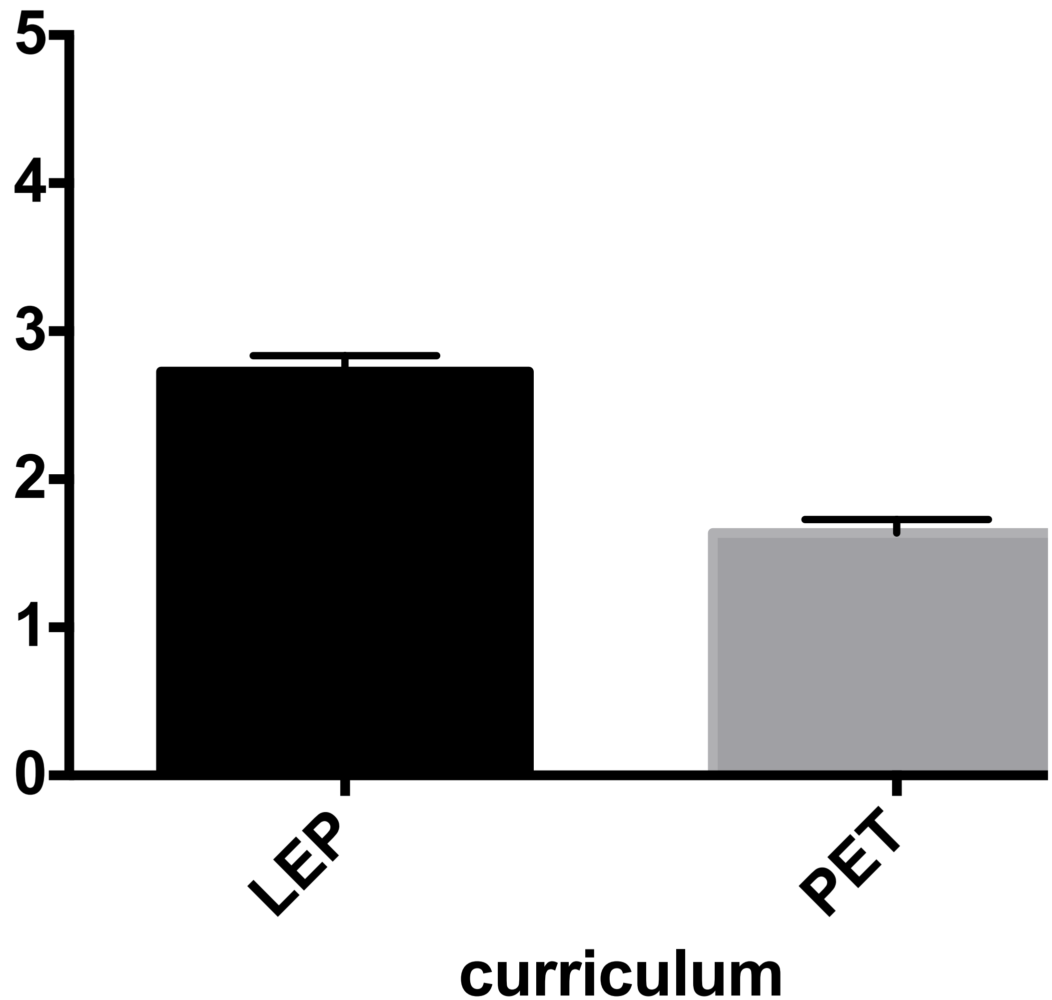
In my diagram, I drew an unmagnetized nail by randomly orienting the tiny magnets inside the nail. The nail is unmagnetized because the magnetic effects

Peer grading and expert grading were equivalent

Hammering made the nail become unmagnetized because when the hammer smashed the magnetized nail with all the tiny magnets perfectly aligned, the tiny magnets became randomly oriented again canceling each other out and producing no magnetic effect.

Final exam performance on written item

Students in courses that included 5 CPR tasks (LEP) outperformed students in courses with traditional assignments (PET)

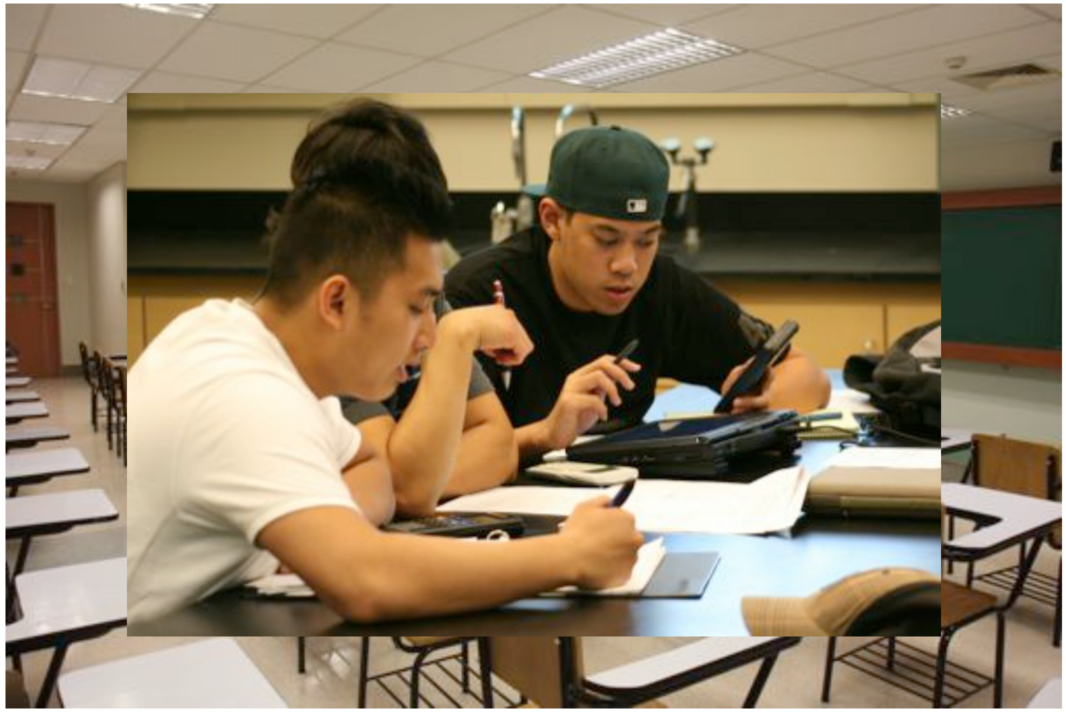


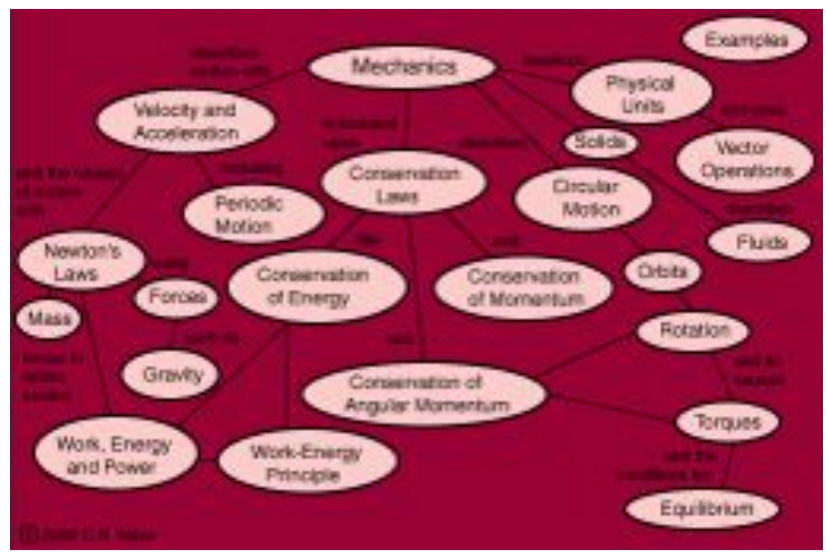
Price, Goldberg, et al., in preparation

CPR as a tool

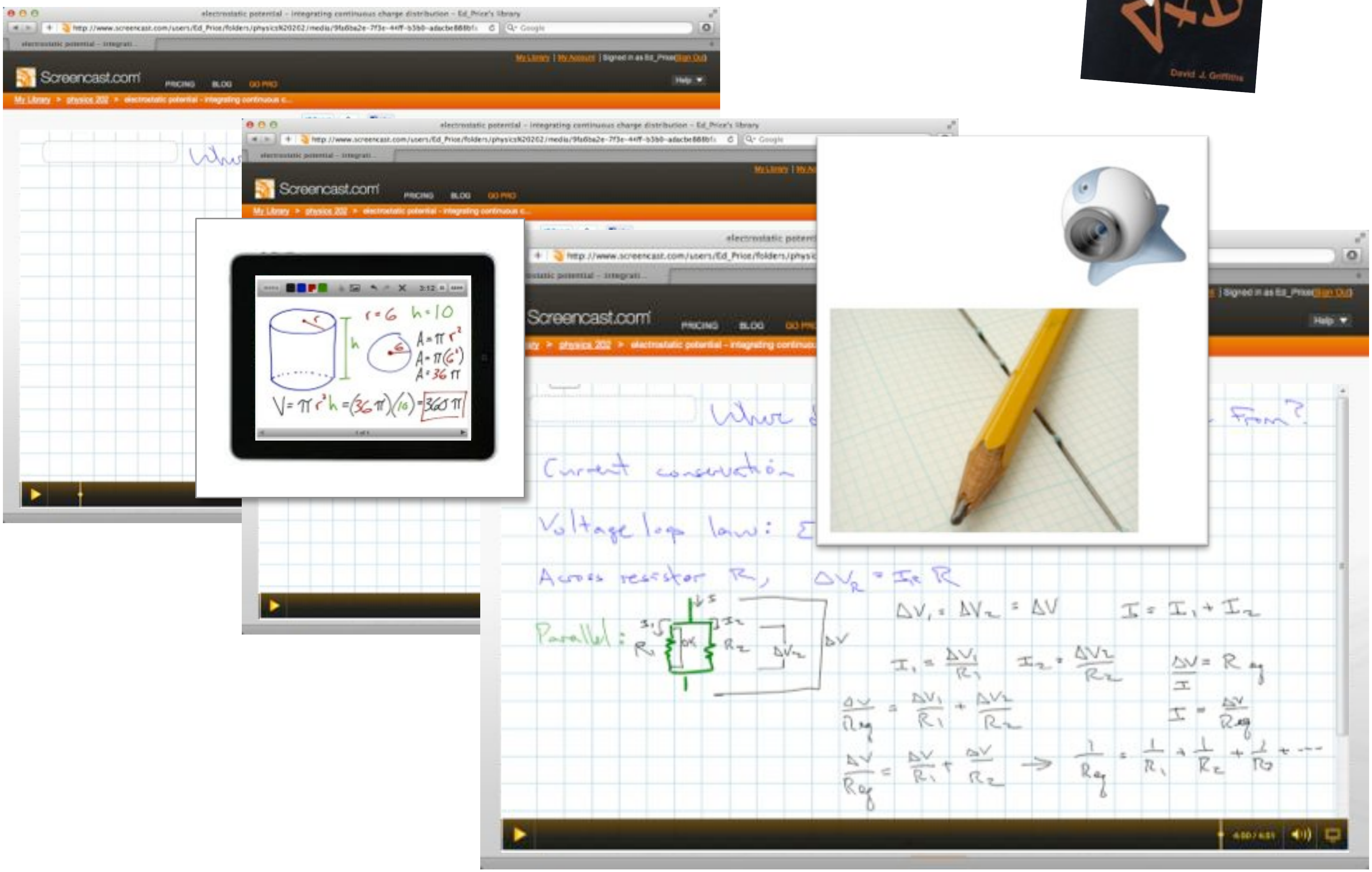
- Supports goal of students being able to construct, critically evaluate explanations
- With CPR,
  - Instructor as developer, but students as graders/evaluators
  - Task development is intensive, but grading/administration is minimal
  - Implicit suggestion that students can develop (some) expertise

FLIPPING THE CLASSROOM




Examples
Mechanics
Physical Units
Velocity and Acceleration
Solids
Vector Operations
Conservation Laws
Circular Motion
Periodic Motion
Fluids
Newton's Laws
Orbits
Conservation of Energy
Conservation of Momentum
Forces
Mass
Rotation
Gravity
Conservation of Angular Momentum
Torques
Work, Energy and Power
Work-Energy Principle
Equilibrium


INTRODUCTION to ELECTRODYNAMICS
Third Edition
David J. Griffiths


electrostatic potential - integrating continuous charge distribution - Ed_Price's library
Screencast.com
PRICING
BLOG
GO PRO
My Library > physics 202 > electrostatic potential - integrating continuous c...
Current conservation
Voltage loop law:
Across resistor R,
Parallel:

For screencasts (and books) and flipped classrooms?

- How can these tools further pedagogical goals?
- How do these tools
  - Reorganize who does what?
  - Change participation?
  - Allow new/different norms?
  - Reinforce/support existing norms?

MOOCS, ONLINE COURSES, & THE WHOLE FUTURE OF EDUCATION

Education

The New York Times

March 4, 2012

Instruction for Masses Knocks Down Campus Walls

By TAMAR LEWIN

The pitch for the online course sounds like a late-night television ad, or maybe a subway poster: "Learn programming in seven weeks starting Feb. 20. We'll teach you enough about computer science that you can build a Web search engine like Google or Yahoo."

But this course, Building a Search Engine, is taught by two prominent computer scientists, Sebastian Thrun, a Stanford research professor and Google fellow, and David Evans, a professor on leave from the University of Virginia.

The big names have been a big draw. Since Udacity, the for-profit startup running the course, opened registration on Jan. 23, more than 90,000 students have enrolled in the search-engine course and another taught by Mr. Thrun, who led the development of Google's self-driving car.

Learning principles

1. Learning builds on prior knowledge
2. Learning is a complex process requiring scaffolding
3. Learning is facilitated through interaction with tools
4. Learning is facilitated through peer interactions
5. Learning is facilitated through establishment of norms and expectations

J. D. Bransford, A. L. Brown, and R. R. Cocking, *How People Learn: Brain, Mind, Experience, and School* (NAP, Washington, D.C., 2000).
E. F. Redish, Implications of Cognitive Studies for Teaching Physics, American Journal of Physics **62**, 796 (1994).
D. Hammer, et al., in *Transfer of Learning: Research and Perspectives*, edited by J. Mestre (Information Age Publishing, 2004).
Y. Engeström, *Learning by Expanding: An Activity-theoretical Approach to Developmental Research* (Orienta-Konsultit Oy, 1987).
M. Cole, *Cultural Psychology: A Once and Future Discipline* (Harvard University Press, Cambridge, MA, 1998).
L. S. Vygotsky, *Thought and Language* (MIT Press, Cambridge, MA, 1986).
E. G. Cohen, *Designing Groupwork: Strategies for the Heterogeneous Classroom* (Teachers College Press, 1994), p. 203.
R. Driver, P. Newton, and J. Osborne, Establishing the Norms of Scientific Argumentation in Classrooms, Science Education **84**, 287-312 (2000).

U.S. DEPARTMENT OF EDUCATION

Evaluation of Evidence-Based Practices in Online Learning

A Meta-Analysis and Review of Online Learning Studies

Students who took all or part of their class online performed better, on average, than those taking the same course through traditional face-to-face instruction. Learning

[differences] may be the product of aspects of those treatment conditions other than the instructional delivery medium per se.

51 contrasts is statistically significant at the $p < .01$ level. Interpretations of this result, however, should take into consideration the fact that online and face-to-face conditions generally differed on multiple dimensions, including the amount of time that learners spent on task. The advantages observed for online learning conditions therefore may be the product of aspects of those treatment conditions other than the instructional delivery medium per se.

MOOCs, online courses, & the future of education

- In these models, what are the implicit (or explicit) theories of learning?
  Are they consistent with research on learning?
  Compared to what?
- Roles of faculty, instructional developers, teachers, students

MOOCs, online courses, & the future of education

- In these models, what are the implicit (or explicit) views about the purposes and mechanisms of education?
- Providing access – of what sort, for whom?
- Who profits?

Technology in the classroom

A classroom is a community, learning is a social process. Technology should be designed and used to support this.

Clickers, video-based experiments, and online archives can extend and enrich the classroom, and support/ structure interactions.

Technology in the classroom

Let pedagogical goals drive the use of technology.
Technology ≠ pedagogy. What you do is more important than the tools you use.
But tools can reorganize activities, roles, and norms.
Keep an eye on the broader context in which we work.

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*

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