Thinking broadly about educational technology

Edward Price
eprice@csusm.edu

Department of Physics
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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... where it should be possible to obtain 100% efficiency.

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_

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?
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. Wood10

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 teaching,” an umbrella term that includes 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

• 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

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

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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

S2: I was thinking that, yeah, C, because it slowed down right when he let go. Like it started slowing.
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
<table>
<thead>
<tr>
<th>Hands on experiments</th>
<th>Videos of experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Some spontaneous experimentation</td>
<td>Only recorded experiment is available</td>
</tr>
<tr>
<td>Unintended set ups, methods, observations</td>
<td>Results are clear and unambiguous</td>
</tr>
<tr>
<td>Group members have varied roles; group dynamics matter</td>
<td>All students have the same role (watch and interpret)</td>
</tr>
<tr>
<td>Different groups sometimes observe different outcomes</td>
<td>All students/groups have access to same observation</td>
</tr>
<tr>
<td>Require more time; pacing different for different groups</td>
<td>Require less time; pacing is uniform for entire class</td>
</tr>
</tbody>
</table>
Student perceptions of hands-on vs videos

Which was most time efficient?

Which best satisfied your curiosity?

Which do you trust the results of more?
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

Text entry stage
- View background material & prompt
- Enter text / upload images

Calibration stage
- Evaluate & score calibration texts
- Receive feedback on calibrations

Peer/self review stage
- Evaluate & score 3 peers’ texts
- Evaluate & score own text
- Review results & feedback

Other students’ texts
- Calibration texts

Evaluation questions and scoring rubric

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 are inconclusive, students share their thinking with whole class.

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.

Peer grading and expert grading were equivalent
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
Current conservation

Voltage loop law: E

Across resistor \( R_1 \):
\[ \Delta V_1 = I \cdot R_1 \]

Parallel:
\[ \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} \]

\[ I_1 = \frac{\Delta V_1}{R_1} \quad I_2 = \frac{\Delta V_1}{R_2} \]

\[ I_1 = I_2 \]

\[ \Delta V_1 = \Delta V_2 = \Delta V_3 \]

\[ I = I_1 + I_2 \]

\[ \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} \]
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
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

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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 outcomes for students who engaged in online learning exceeded those of students receiving face-to-face instruction, with an average effect size of +0.24 favoring online conditions. The mean difference between online and face-to-face conditions across the 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


Norman (1988) *The Psychology of Everyday Things*


