Sustaining Educational Innovations

Evidence and Approaches at CU Boulder

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Overview of PER

• Investigating education scientifically
• Far more to our classes than what is traditionally evaluated

• Physics education research has something to say about this
  – Models of student learning
  – Tools for measurements
  – evidence of impact
  – curricula / approaches

Theory
Experiment
Application
PER Theoretic Background

Individual transmissionist

Instruction via transmission

Content (E/M)

Individual

Active construction

Prior knowledge

Content

constructivist
Take home message:

*Students learn less than 25% of the most basic concepts (that they don’t already know).*

R. Hake, “…A six-thousand-student survey…” AJP 66, 64-74 (‘98).
Many PER curricular innovations
by actively engaging students...
R. Hake, "...A six-thousand-student survey..." AJP 66, 64-74 ('98).
modest reframing of class context
U. Washington Tutorials
50 min/wk, 30 students, 1 grad TA
+ undergrad Learning Assistant
(Weekly prep + LA seminar)

- Phys lecture
  3-600 students
  3 lectures/wk
  (No lab)

- Online HW System
  CAPA or MP

- Interactive Lectures
  Peer Instruction,
  pers. resp. system

- Text
  trad or PER based
Transformations at CU

Peer Instruction
Eric Mazur

Interactive Lecture Demonstrations
Active Learning in Introductory Physics
David R. Sokoloff
Ronald K. Thornton

Just-in-Time Teaching:
Blending Active Learning with Web Technology

Tutorials
Introductory Physics
Lillian G. McDermott, Peer S. Shaffer
Department of Physics
University of Washington
Tutorials in Introductory Physics

Reconceptualize Recitation Sections

• Materials
• Classroom format / interaction
• Instructional Role
• Use of Learning Assistants
CU Model of Teacher Prep

• Begin *within* physics department

• Learning Assistants:  
  Use UG’s to implement PER-based materials  
  – Model best-practices for all students  
  – Improve education of all students  
  – Increase likelihood students engage in teaching

• Improve content mastery of future teachers

Tutorial vs. Trad'l Recitation
Tutorial
Reproducibility

<table>
<thead>
<tr>
<th>Topic</th>
<th>U. Wash. no tutorial</th>
<th>UW tutorial</th>
<th>CU tutorial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newton &amp; constraints</td>
<td>45%</td>
<td>70%</td>
<td>75%</td>
</tr>
<tr>
<td>Force diagrams</td>
<td>30%</td>
<td>90%</td>
<td>95%</td>
</tr>
<tr>
<td>Newton’s III law</td>
<td>15%</td>
<td>70%</td>
<td>70%</td>
</tr>
<tr>
<td>Combine Newton’s laws</td>
<td>35%</td>
<td>80%</td>
<td>80%</td>
</tr>
</tbody>
</table>

CU: Pre- Post FMCE scores

Beyond the FMCE: Exam comparisons

N.B. 12 points is roughly 1 letter grade.
Is the recitation curriculum all that matters?

_instructor effects_?
Back to the FCI/FMCE

traditional lecture interactive engagement

\[ \langle g \rangle = \frac{\text{post-pre}}{100-\text{pre}} \]

R. Hake, "...A six-thousand-student survey..." AJP 66, 64-74 (‘98).
Replication, but with strong variations Why?
1120 BEMA pre/post

F04 (N=319) Post: 59%  S05 (N=232): 59%

does it last?
Longitudinal

Upper division majors’ BEMA scores

Yellow: students who had been E&M LAs

S. Pollock, 2007 PERC Proc. 951, p.172
Conclusions

• Educational practice is a researchable endeavor
  – We can make systematic progress
  – Imperative to include scientists
• Possible to achieve dramatic repeated results
  – Build on/adapting research-based curricula
• CU model strongly couples:
  – Reform and Research
  – K12 Teacher prep

It’s not about our teaching, it’s about student learning
Questions?

Much more at: per.colorado.edu
Or stem.colorado.edu