Building on a Base:
Applying Physics Education Research to Physics Teaching

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(With thanks to N. Finkelstein!)

Thanks for support from:
Pew/Carnegie CASTL,
NSF CCLI
NSF STEM-TP
PhysTec
Overview

• Physics Education Research (PER) Rapid growth, subfield of physics

• A Physicist’s History:
  Research on student concepts (Arons, McDermott, ...)
  Concept Inventories (Halloun, Hestenes, Hake, ...)
  Curriculum (Washington, Maryland, Mazur, many...)
  Theoretical Frames (Redish, diSessa, many...)
In recent years, physics education research has emerged as a topic of research within physics departments. ... The APS applauds and supports the acceptance in physics departments of research in physics education.

-The American Physical Society
Statement 99.2 Research in Physics Education (May 1999)
Professional recognition

- Journals (AJP, and Physical Review)
- NSF funding
- >50 institutions with PER groups
What won’t I cover

Lots!

• Details of curricula/research based reforms
• High school or advanced undergrad
• Survey of current research topics
Data on student conceptions

Interviews/open questions

• Prior knowledge
• Basis for surveys and curriculum reform

(e.g. Arons, McDermott, ...
A possible “tilting” development

• **Force Concept Inventory** (Hestenes, Wells, Swackhamer, Physics Teacher 20, (92) 141, Halloun and Hestenes)

• Multiple choice survey, (pre/post)

• Experts (especially skeptics!) => necessary (not sufficient) indicator of conceptual understanding.
Sample question
Value of FCI

- Based on research
- Refocus on concepts
- Quantitative basis for comparing curricula
- Wake up call
Force Concept Inventory (FCI)

red = trad, blue = interactive engagement

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

R. Hake, "...A six-thousand-student survey..." AJP 66, 64-74 ('98).
Next steps

Conceptual survey development www.flaguide.org

Attitudes/student epistemology

Research on student understanding
  -> guide to curricular reforms
  -> incorporate cognitive theories
Attitudes and Beliefs

VASS, MPEX, CLASS, ... (e.g. Saul, Redish, PER@C,...)

Assessing the “hidden curriculum”

Examples:
“"I study physics to learn knowledge that will be useful in life.""
"To learn physics, I only need to memorize solutions to sample problems"
(Typical) attitude shifts

W. Adams 2003, replicating Redish, Steinberg, Saul  AJP 66 p. 212 (‘98)
Curriculum reform

ConcepTests (Mazur) (easy to implement)
Tutorials (McDermott) (modest infrastructure)
Workshop physics (Laws) (resource intensive)

And many more - can’t do justice!
Interactive Lect Demos (Thornton, Sokoloff)
Problem solving (Van Heuvelen, Heller,...)

Based on empirical research
Next generation: cognitive theory as well.
Reproducibility
Primary/secondary implementation of “Tutorials”

<table>
<thead>
<tr>
<th>Topic</th>
<th>U. Wash. no tutorial</th>
<th>U. Wash. with tutorial</th>
<th>CU with tutorial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newton’s law &amp; tension</td>
<td>25%</td>
<td>50%</td>
<td>55%</td>
</tr>
<tr>
<td>Newton &amp; constraints</td>
<td>45%</td>
<td>70%</td>
<td>45%/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>

Rounding all results to nearest 5%
Theoretical frameworks

- functionalist/neural/working memory
- Constructivism
- Context dependence/situated cognition
- Socio-cultural elements
Examples of “building on a base”:

**PER@C** group: http://per.colorado.edu

- Secondary implementations
- Research based sims
- CLASS survey
- Theoretical perspectives

...
Building on a base

- Theoretical frames
- Student concepts and engagement
- Curricular reforms
- Classroom practice
- Data
Summary

• State of PER: beyond “reflective teaching”
• Data driven
• Published/publishable results
• Reproducible across institutions
• Changing culture of departments (?!)

The end

See:
www.flaguide.org
per.colorado.edu
www2.physics.umd.edu/~redish/Book/
CU reformed course Fa 03

FCI scores
Phys 1110 Fa ’03

Score (%)

# of students

FCI Pre
FCI Post