Testing Conceptual Understanding and Student Attitudes

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Measuring conceptual mastery in mechanics

- Force Concept Inventory - basic concepts of force and motion 1st semester physics

Force Concept Inventory

Ask at start and end of semester— What % learned?

(post-test) – (pre-test)  
(maximum) – (pre-test)

On average learn <30% of concepts did not already know. Lecturer quality, class size, institution,...doesn’t matter! Similar data for conceptual learning in other courses.

R. Hake, "...A six-thousand-student survey…” AJP 66, 64-74 (‘98).
Red bars are traditional lecture. Green are various interactive engagement methods.

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Force Concept Inventory

- Broad deployment of FCI undertaken in many UBC freshman mechanics courses in 2008/2009

- Pre-test results:

  - PHYS 107 (enriched freshman physics) – 78%
  - PHYS 170 (mechanics for engineers) – 63%
  - Science I (1997) – 73%

  - PHYS 101 (winter term after PHYS 100, no Physics 12) – 46%

Serious curriculum implications for students without Physics 12 – consider a different stream of courses than current 100/101/102 sequence.
Measuring mastery in basic Electricity&Magnetism

• Brief Electricity and Magnetism Assessment (BEMA)

• developed by Chabay and Sherwood in 1997 (AAPT Announcer 27, p. 96)

Has been used to assess changes to freshman course at University of Colorado

Given to all first year freshman physics classes in 2008/2009
Comparative data on BEMA

- third year scores suggest problems basic understanding and retention
- solution is U.Wash. tutorials and other U. Colorado practices
Physics Lab Diagnostic: building something from scratch

10 multiple choice questions

distractor options based on student answers from earlier written version

questions validated through 12 student interviews

probes the students' ability to:

ruminate upon measurement uncertainty and basic statistics

make connections between data and mathematical models

Sample question: Student A measures the flow rate of water coming from a tap and reports it to be \((90 \pm 12)\) millilitres per second. Student B follows a different measurement procedure and reports the flow rate to be \((110 \pm 1)\) millilitres per second. How long would it take to fill a 1 litre container?

(a) 10.0 s  (b) 9.1 s  (c) 11.1 s  (d) 9.5 s  (e) 10.6 s
Pre-test results

ScienceOne (71): 2.8 ± 0.2
Phys 107/109 (49): 2.8 ± 0.2
Phys 101 (254): 2.3 ± 0.1
U of Edinburgh 1st year (249): 2.3 ± 0.1
Phys 209 (83): 4.0 ± 0.2
Phys 259 (59): 3.2 ± 0.2
Phys 409 (17): 4.1 ± 0.5
Phys 449 (17): 4.1 ± 0.5
graduate students (11): 7.5 ± 0.3
Post-test results
(April 2009)

ScienceOne (71): 4.4 ± 0.3
Phys 107/109 (47): 3.9 ± 0.3
The CLASS Survey
(Colorado Learning Attitudes about Science Survey)

- Developed by Wendy Adams and co-workers at UC-Boulder
- Analysis of UBC Physics&Astronomy data by Louis Deslauriers
- Main Goals:
  - Focus on *beliefs about the discipline and learning the discipline*
  - Valid/Reliable across university populations (non-sci to majors)
  - Probe additional facets of beliefs (problem solving)

Strongly Disagree  1  2  3  4  5  Strongly Agree

*I think about the physics I experience in everyday life.*

*It is possible to explain physics ideas without mathematical formulas.*
Surveyed beliefs: UBC and CU

- Students who choose to major in physics see physics as highly relevant and useful in everyday life.

(CU Calc-based Phys I)

- 1st yr Phys majors
- Whole class mostly engineers
- Bio & Chem

(CU Alg-based Phys I)

- UBC 1st yr Phys153
- UBC 1st yr Phys107
- Non-sci majors
- Elementary ed majors
- UBC 1st yr Phys100
- UBC 1st yr Phys101
- UBC 1st yr Sci One

% Favorable Score (PRE)
Impact of teaching on students’ beliefs

- MPEX work in Physics: Students’ expectations shift to be more novice (decline of ~5-8% in ‘Overall’ %fav)
- CLASS-Phys results at CU-Boulder:
- CLASS-Phys Fall 2008 results at UBC:

![Diagram showing shift in % Favorable (Post minus Pre)]

Overall

Shift in % Favorable (Post minus Pre)

- **CU Calc-based Phys I**
- **UBC Phys 100**
- **CU Calc-based Phys II**
- **UBC Phys 101**
- **UBC Calc-based Phys II**
- **UBC Phys 153**
- **UBC Alg-based Phys I**
- **UBC Science One**
- **UBC Phys 107**
Conclusions

A concerted effort at widespread diagnostic testing can:

- Inform decisions on curriculum
- Support the case for adopting new teaching techniques
- Test the results of new teaching methods
- Can be used to stream students