Testing Conceptual Understanding and Student Attitudes

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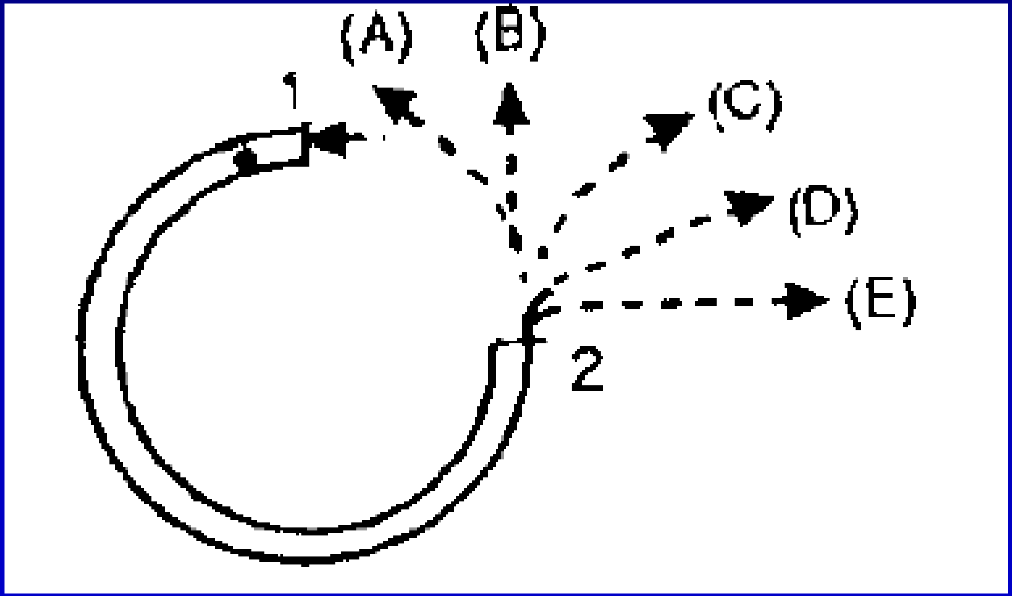
Measuring conceptual mastery in mechanics

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

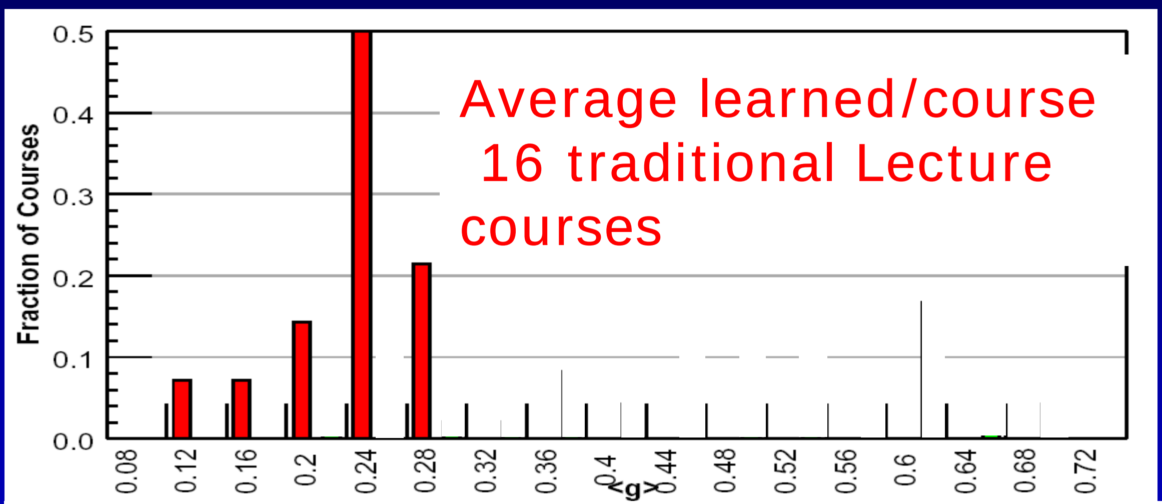
- developed by Halloun and Hestenes in 1984
(Am. J. Phys. 53, p. 1043)



Force Concept Inventory

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

$$\frac{\text{(post-test)} - \text{(pre-test)}}{\text{(maximum)} - \text{(pre-test)}}$$



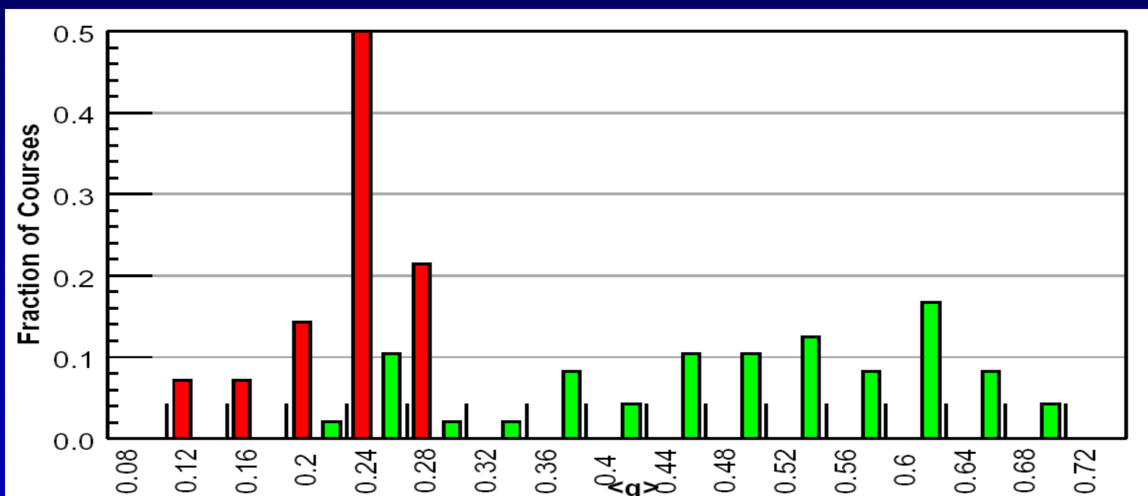
Fraction of unknown basic concepts learned

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.

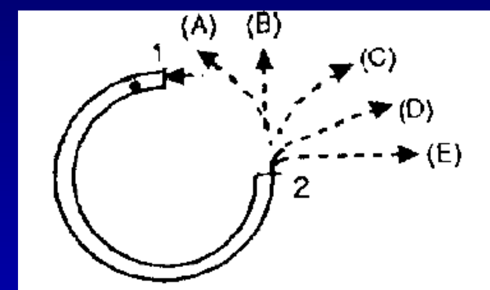
R. Hake, "…A six-thousand-student survey…" AJP 66, 64-74 ('98).

Force Concept Inventory

Red bars are traditional lecture. Green are various interactive engagement methods.



Fraction of unknown basic concepts learned



R. Hake, ”…A six-thousand-student survey…” AJP 66, 64-74 (‘98).

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

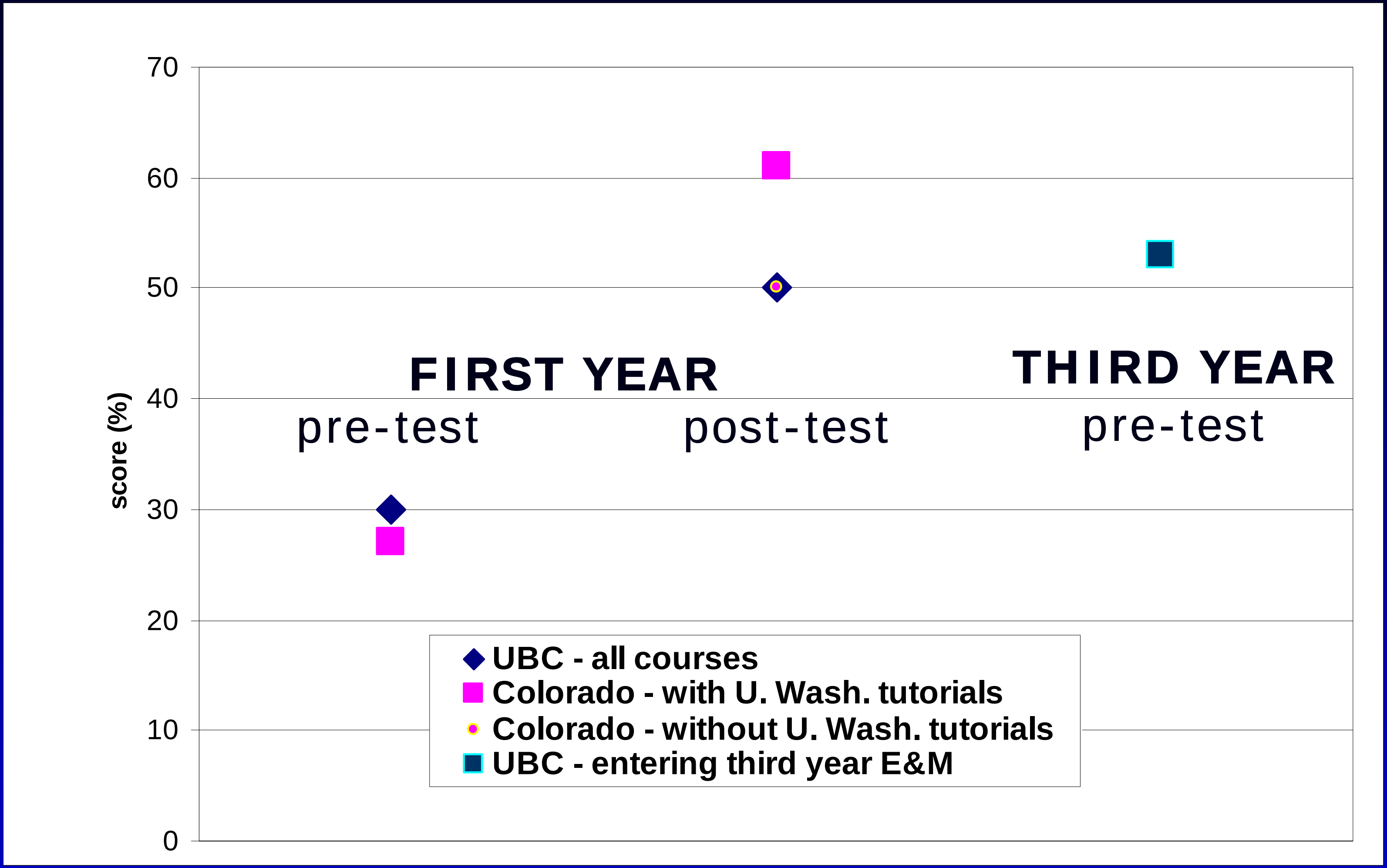
- Brief Electricity and Magnetism Assessment (BEMA)

- 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

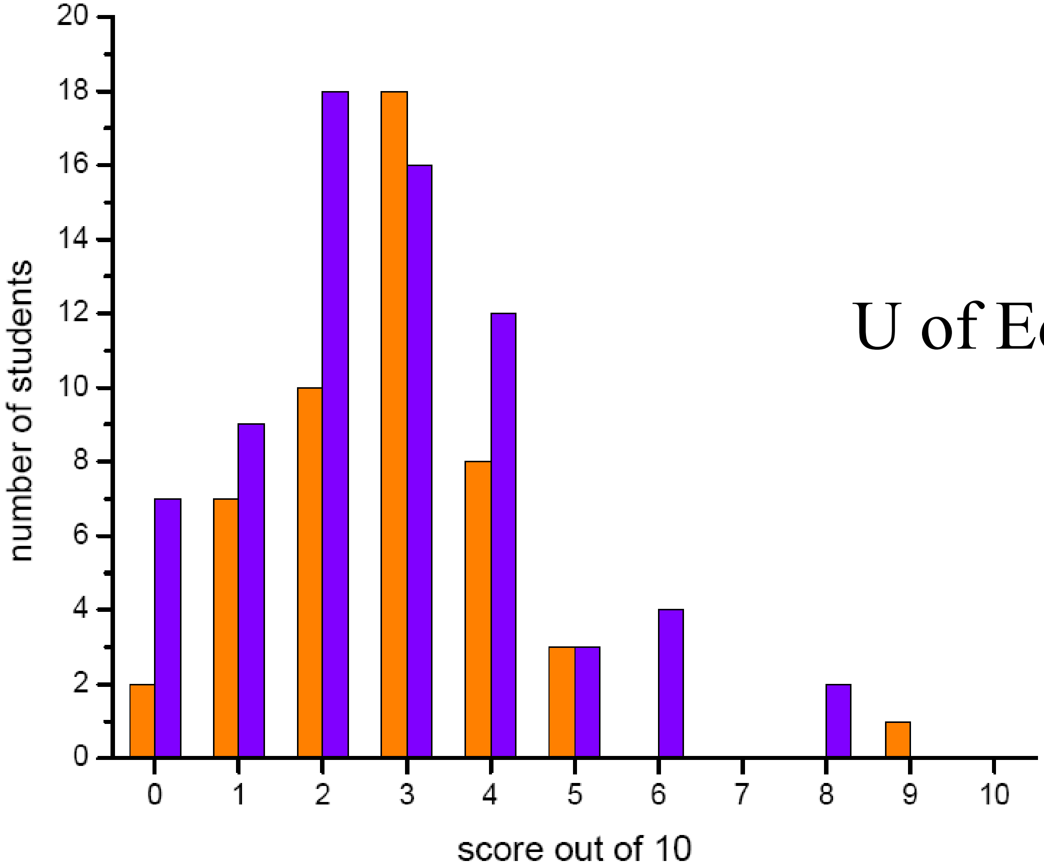
probes the students' ability to:

- 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 ± 12) millilitres per second. Student B follows a different measurement procedure and reports the flow rate to be (110 ± 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

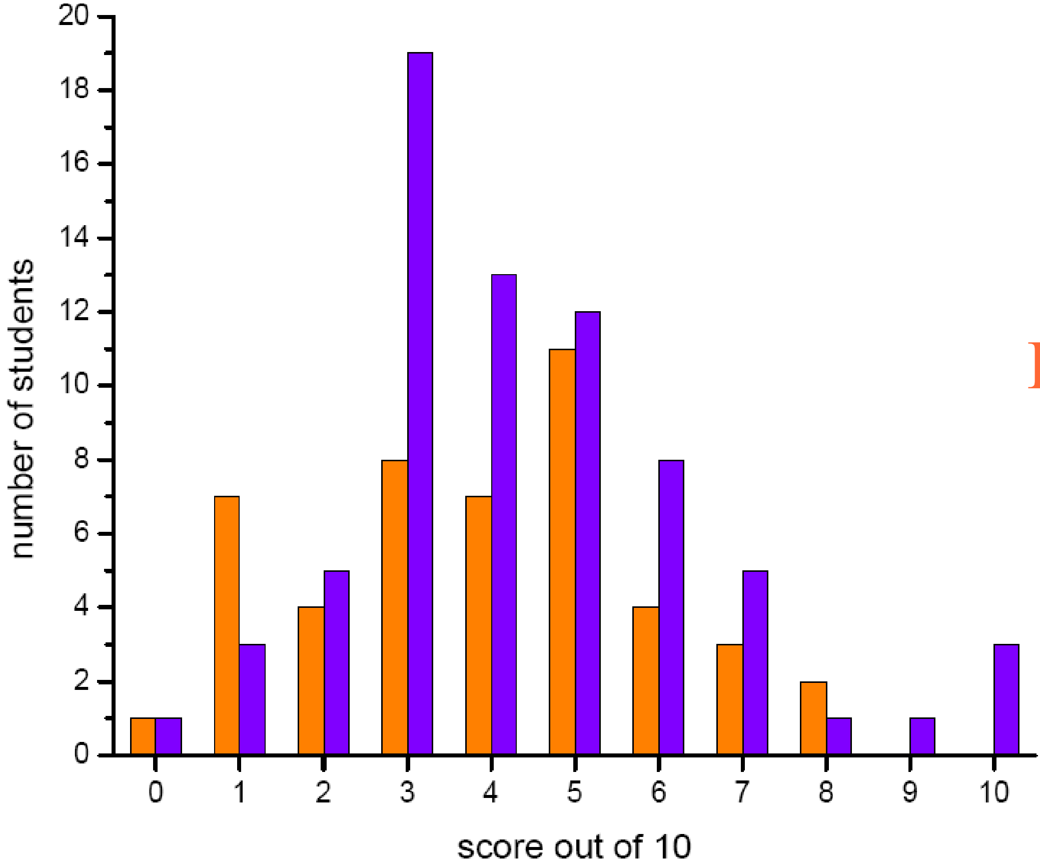
Phys 259 (59): 3.2 ± 0.2

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)

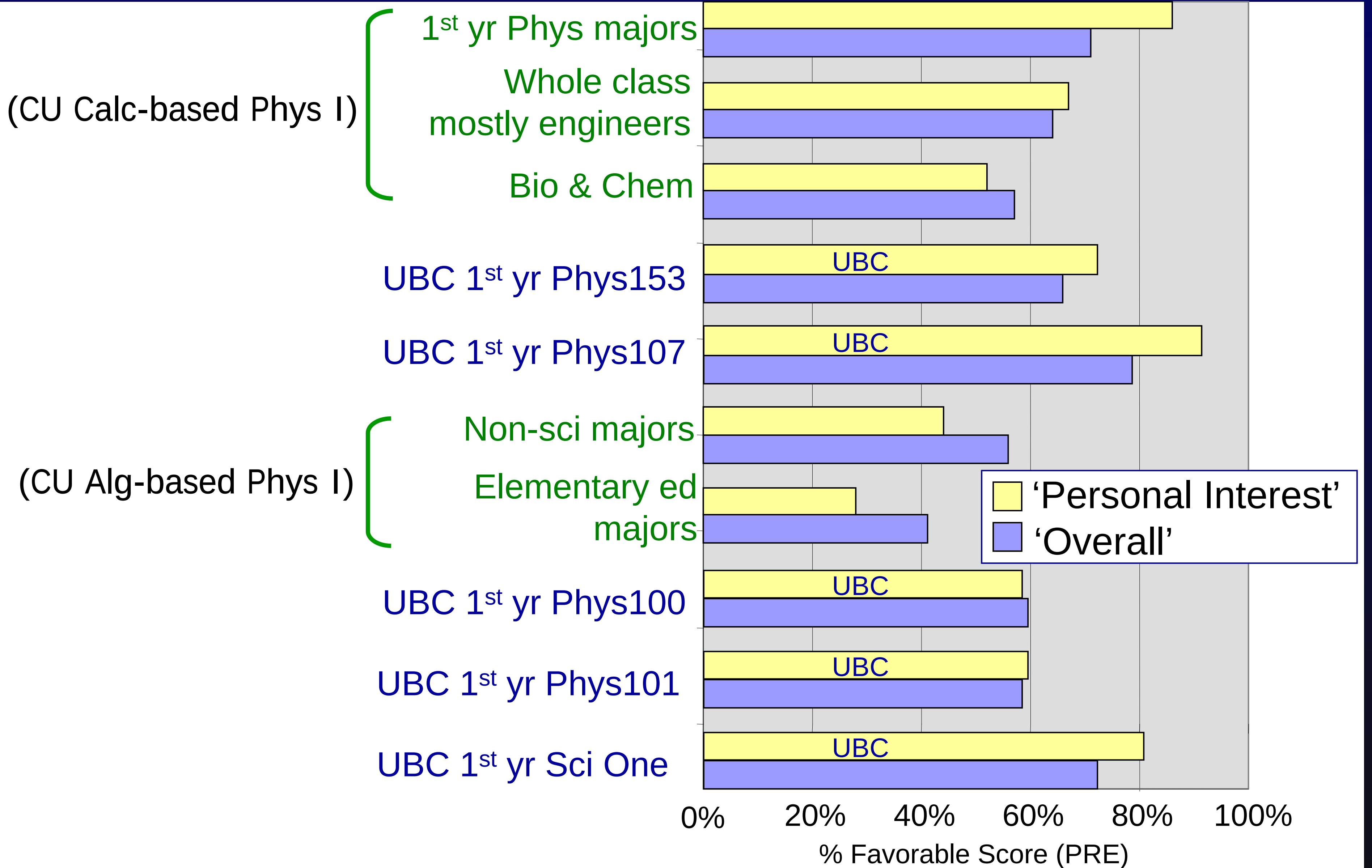
Strongly Disagree 1 2 3 4 5 Strongly Agree

I think about the physics I experience in everyday life.

It is possible to explain physics ideas without mathematical formulas.

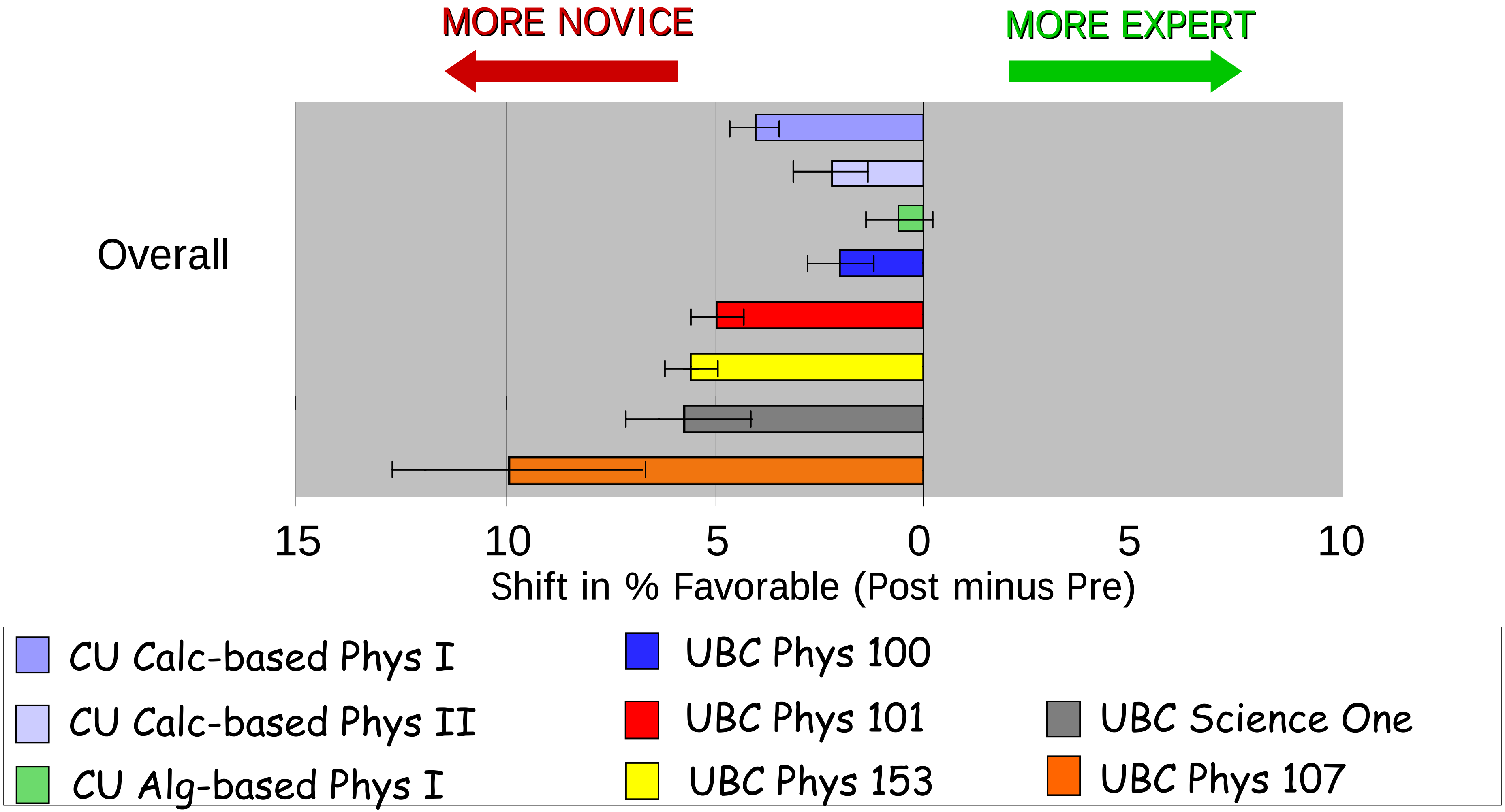
Surveyed beliefs: UBC and CU

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



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:



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