Assessment and Evaluation in College Physics

Noah Finkelstein
Department of Physics
University of Colorado **Boulder**

Edward Price
Department of Physics
Cal State Univ. San Marcos

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Exp. Faculty Workshop
AAPT, AAS, AIP, APS
College Park, MD

California State University
SAN MARCOS

Warm-Up

Reflect on a session / course / teaching experience that was really good.

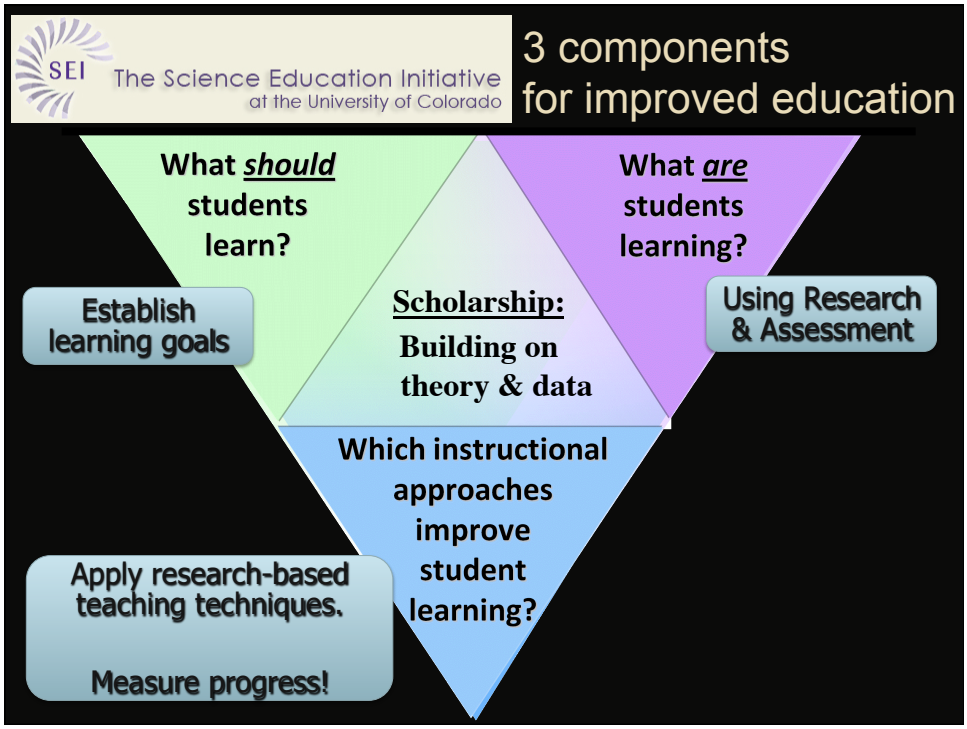
How do you know that the experience was good?

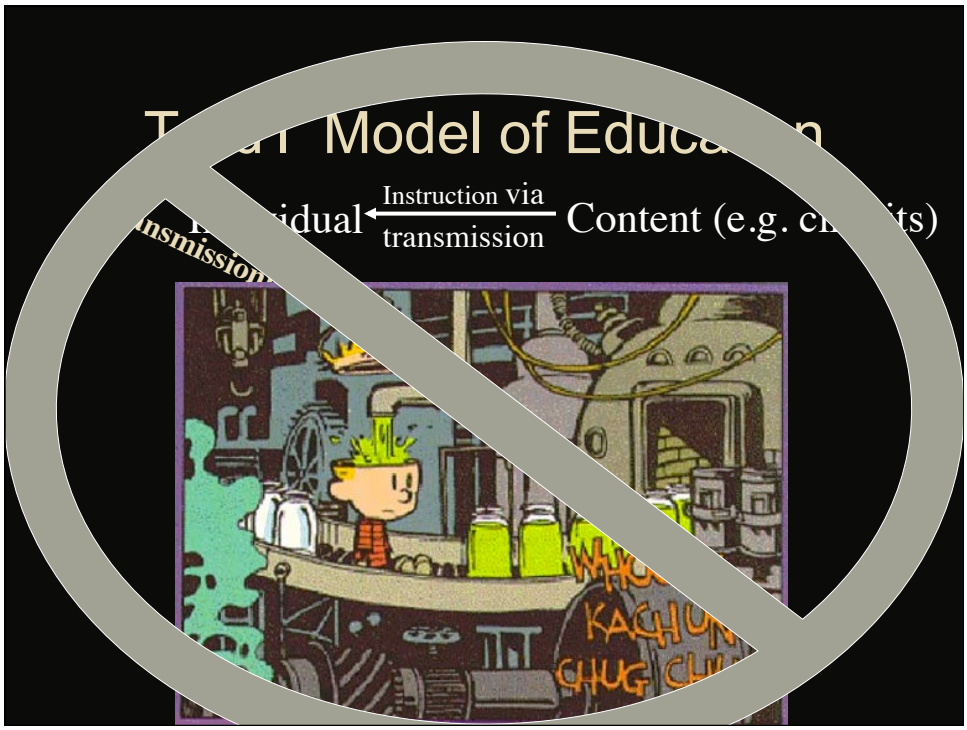
what evidence do you use to backup the claims of effectiveness?

Goals

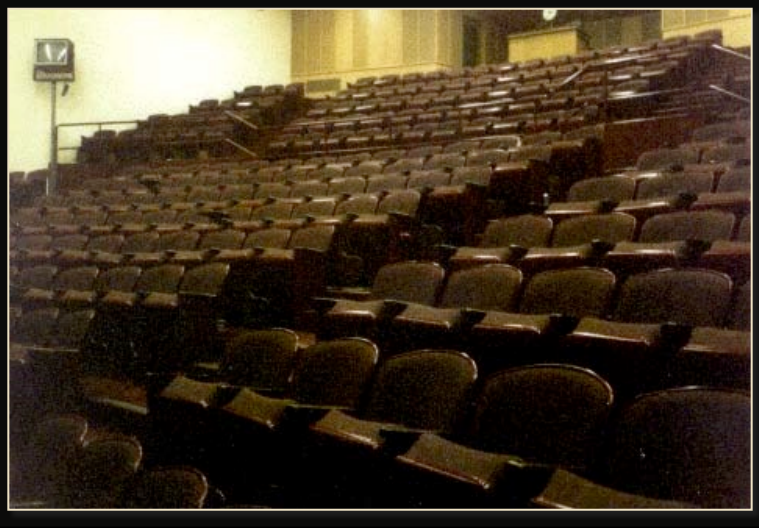
- Shift Emphasis: from *teaching* to *learning*
  - Theory & Model
- Argue for a Scholarly Approach -
  - Methodology
- Share Resources
  - Implementation

making a scholarship out of education transformation


SEI
The Science Education Initiative
at the University of Colorado
3 components
for improved education
What *should* students learn?
What *are* students learning?
Establish learning goals
Scholarship:
Building on theory & data
Using Research & Assessment
Which instructional approaches improve student learning?
Apply research-based teaching techniques.
Measure progress!


Model of Educa
Instruction via transmission
Content (e.g. cr its)
KACHUN
CHUG CH

Built in to our classes?



Where does our model come from…

– Sumer, circa 3000 BCE

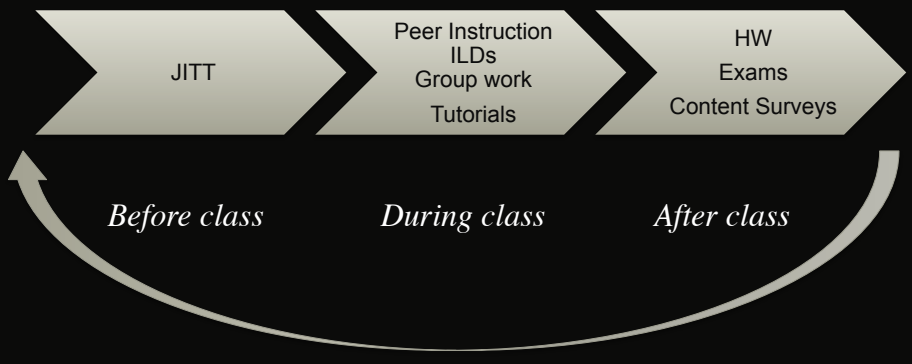
Assessment is about Feedback (and acting on that feedback)

to *whom*?

for *what* reason?

& *when* ?

When to assess



What to Assess?

- In order to care about assessment outcomes, you first need to establish course goals.
- What do you want to accomplish? What are your top two or three goals for your course?

Learning Goals

What are our goals in class?

Novice		Expert
Formulas & "plug 'n chug"	content	Concepts & Problem Solving
Pieces	structure	Coherence
By Authority	process	Independent (experiment)
Drudgery	affect	Joy

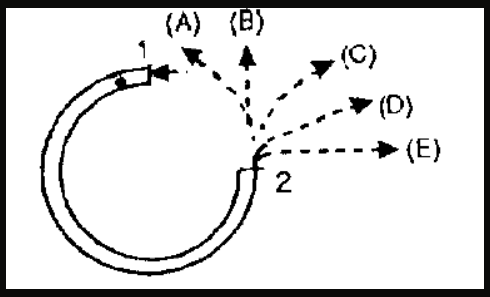
think about science like a scientist
think about education like a scientist

Adapted from: Hammer (1997) COGNITION AND INSTRUCTION (physics),

What are we assessing

Introductory Sequence
Conceptual

Sample question



Looking down at a track (flat on table), a ball enters at point 1 and exits at point 2. Which path does it follow as it exits (neglect all friction)?

FCI, Hestenes et al, 1986

Upper Division

S. Pollock
S. Chasteen, R. Pepper, K. Perkins
D. Caballero, C. Baily, B. Wilcox

Why transform upper division?

Lecture with clickers

?

Washington Tutorials

Can our majors learn better from interactive techniques adapted from introductory physics?

Categories of Assessments: Examples – Conceptual Surveys♪

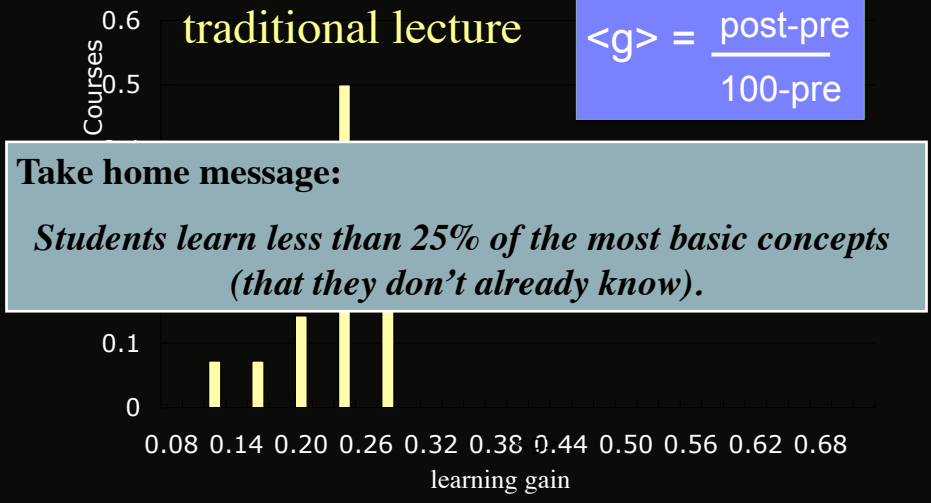
- ✓ Force Concept Inventory (FCI)
- ✓ Force/Motion Conceptual Evaluation (FMCE)
- ✓ Mechanics Baseline Exam (MBE)
- ✓ Electric Circuits Concept Evaluation (ECCE)
- ✓ Conceptual Survey in Electricity and Magnetism (CSEM)
- ✓ Conservation of Energy/Momentum
- ✓ Waves
- ✓ Thermodynamics

OTHERS

Review♪

- ✓ Conceptual Survey of your Choice
  - ✓ Is this aligned with your goals?
  - ✓ Does this look like physics?
  - ✓ What would you imagine students responses to be?

We are not teaching students



Take home message:

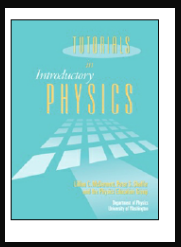
Students learn less than 25% of the most basic concepts (that they don't already know).

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

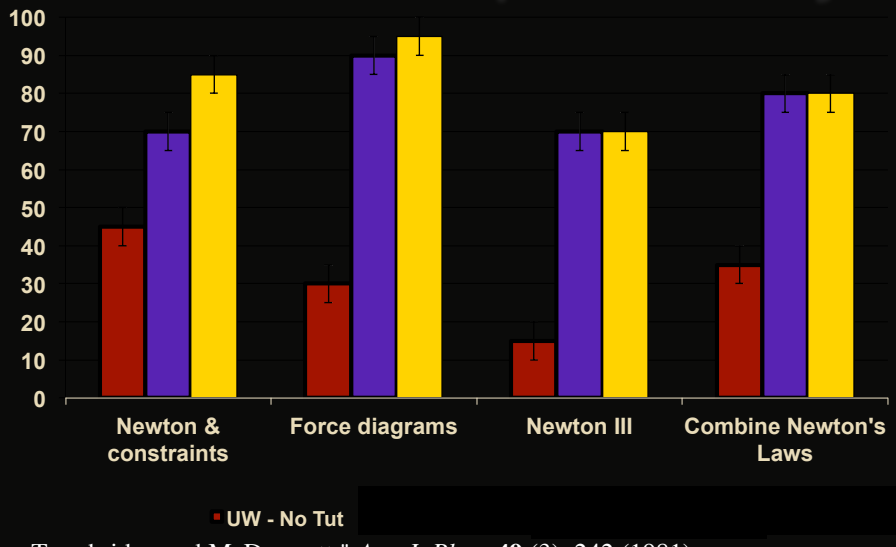
Tutorials in Introductory Physics

Reconceptualize Recitation Sections

- Materials
- Classroom format / interaction
- Instructional Role



Impact and Reproducibility

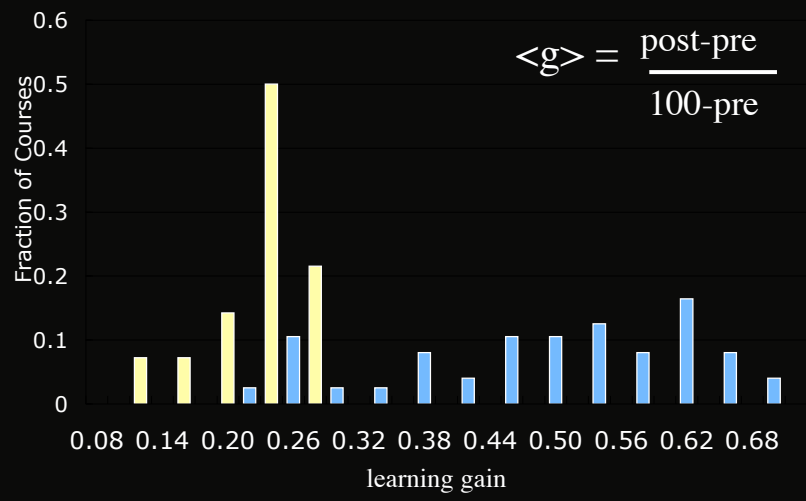


Trowbridge and McDermott," *Am. J. Phys.* **49** (3), 242 (1981).

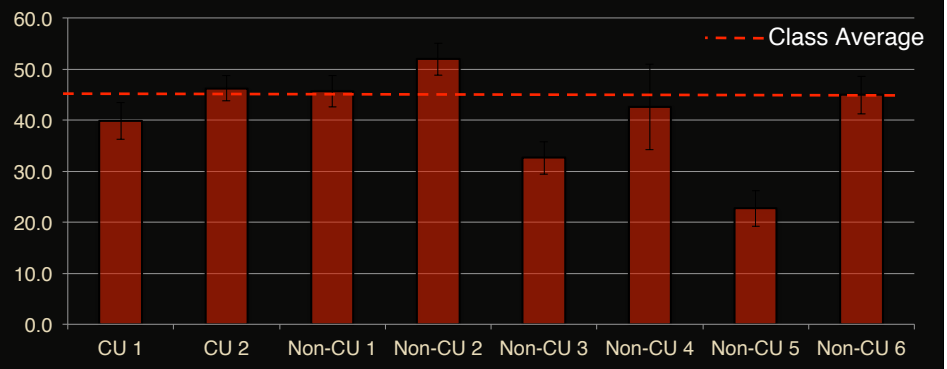
Finkelstein and Pollock, (2005). *Phys Rev ST PER*, 1,1.010101

Engagement Improves Learning

traditional lecture interactive engagement



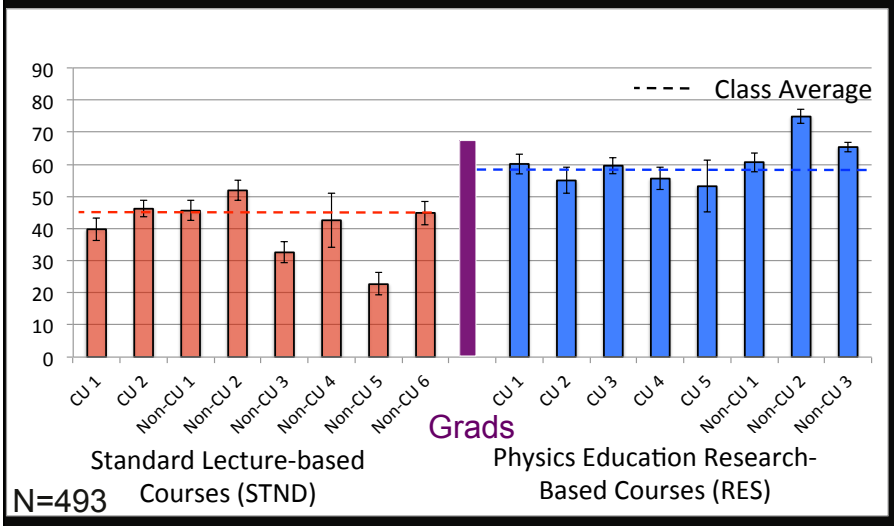
CUE results: Trad courses



Standard Lecture-based Courses (STND)

Chasteen et al, PERC 2011, submitted to AJP

CUE Results: Comparison



Chasteen et al, PERC 2011, submitted to AJP

What are we assessing

Attitudes and Beliefs

Attitudes & Beliefs:

Attitudes and Beliefs

Assessing the "hidden curriculum" - beliefs about physics and learning physics

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"

Adams et al, (2006). Physical Review: Spec. Topics: PER, 0201010

Review♪

- ✓ Beliefs…
  - ✓ Is this aligned with your goals?
  - ✓ Does this look like physics?
  - ✓ What would you imagine students responses to be?

  What would you change to make this for experimental physics?

CLASS categories

	Shift (%) ("reformed" class)
Real world connect...	-6
Personal interest.....	-8
Sense making/effort...	-12
Conceptual.....	-11
Math understanding...	-10
Problem Solving.....	-7
Confidence.....	-17
Nature of science.....	+5

(All ±2%)

Some mechanics …

Why don’t we post solutions?

Why don’t we just make up our own?

Two words re: assessment design

- Validity
- Reliability

Or: It's Difficult…

Or: Beg & Borrow . . .

How Do I Use these?

What do I do with the results?

perusersguide.org (soon)

Resources and Guides for Use/Interpretation

I. At the lower division included are:
- The Force and Motion Conceptual Evaluation (FMCE)
- The Force Concept Inventory (FCI)
- The Brief Electricity and Magnetism Survey (BEMA)
- The Conceptual Survey of Electricity and Magnetism (CSEM)

II. At the Upper division we include materials in development at CU
- Classical Mechanics (CCMI)
- Electrostatics (CUE)
- Electrodynamics (CURrENT)
- Quantum Mechanics (QMAT)

III. And two Beliefs Instruments:
- Colorado Learning Attitudes about Science Survey (CLASS)
- E-CLASS (version for experimental physics)

Email me

What types of assessment should you do?

Answering requires
- Clear identification of goals
- Consideration of what is measurable

Goals for Assessment

- Improve a learning opportunity
  - Concept test
  - develop skills of scientific practice (talking, justifying, arguing, logically deducing . . .)
- Improve a lecture period / unit
  - conceptual mastery
  - problem solving acuity
- Improve a course
- Improve the department
- Improve society?

Categories of Assessments: Formative assessments♪

In class

- Minute Papers
  - 1 min write on "Most important thing you learned during class today?" and "What important question remains unanswered?" or "What is the muddiest point in [example, concept, lecture, chapter]?
- Problem recognition
  - Show several examples, students identify problem type or principle involved
- Application Generation
  - "Give 2 applications of Newton's 3rd law to everyday life."
- Concept tests

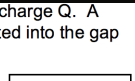
Concept Tests

- Allow students to **discuss & debate challenging, high-level ideas**

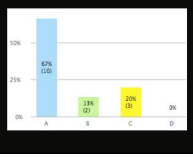
An ideal (large) capacitor has charge Q. A neutral *linear* dielectric is inserted into the gap (with given dielectric constant)

Where is D discontinuous?

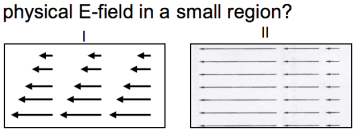
i) near the free charges on the plates
ii) near the bound charges on the dielectric surface



A) i only B) ii only C) i and ii ONLY
D) i and ii but also other places E) none of these/other



Which of the following *could* be a static physical E-field in a small region?



A) Both B) Only I C) Only II D) Neither

Concept Tests

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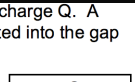

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Freely Available Resources:

- Banks of Clicker Questions
  - Upper-level courses
  - Intro-level too
- Clicker Video Guides for Teachers

per.colorado.edu
www.colorado.edu/sei
http://www.cwsei.ubc.ca/resources/SEI_video.html

Concept Tests

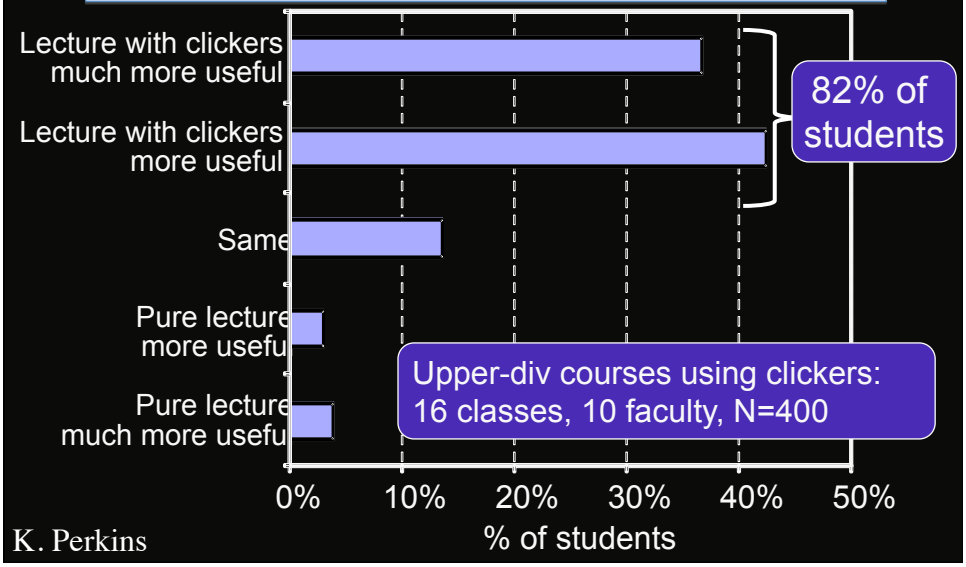
- Feedback to instructor

"Sometimes you get these incredible surprises on things you always thought were very trivial, and simple... clickers helped me understand how little the students are getting from lectures"

"I found it incredibly useful as feedback for me, because [if students didn't understand] I could address it… right then"

Students Find Clickers Useful

Q: How <u>useful for your learning</u> is the addition of clicker questions compared to pure lecture with no clicker questions?



K. Perkins

Grading as assessment?

- Scores don't tell much
  (harsh or easy grader?)
- Rubrics
- Scoring codes

Categories of Assessments: Assignments and exams♪

- Rubrics
  - Specify performance criteria
  - Help students see learning goals; guide efforts
  - Guide instructor grading
- Scoring codes
  - More feedback to students (but more generic)
  - Evaluate frequency of different approaches/errors
- New Models of exams
  - Two-stage exams
  - Standards based
  - Practicing what we teach

Example rubric

	Ability to design and conduct a testing experiment			
Scientific ability	0 (Missing)	1 (Inadequate)	2 (Needs some improvement)	3 (Adequate)
Is able to design a reliable experiment that tests the relationship or explanation.	The experiment does not test the relationship or explanation.	The experiment tests the relationship or explanation, but due to the nature of the design it is likely the data will lead to an incorrect judgment.	The experiment tests the relationship or explanation, but due to the nature of the design there is a moderate chance the data will lead to an inconclusive judgment.	The experiment tests the relationship or explanation and had a high likelihood of producing data that will lead to a conclusive judgment.

Etkina, et al., PRST-PER **2**, 020103 (2006)

Example scoring code

Problem 5
This problem can be analyzed through conservation of momentum. The carts' initial momentum is not zero. This is similar to example 9.3, except that the carts do not start at rest. Problem solving strategy 9.1 on p251 is useful here.

Code	Description
G	Good job
H	Used conservation of momentum approach, but made a minor calculation error, most commonly a sign error with the final momentum of the light cart (remember, it is going opposite to it's initial direction, you have to represent this in the math).
I	Used conservation of momentum approach, but made a physics error in the solution. The most common error was not including the two cart's initial momentum (remember, they are moving to the right when the spring goes off).
J	Tried to solve the problem with conservation of kinetic energy. While mechanical energy *is* conserved in this situation, you must include the spring's potential energy, which is converted to kinetic energy. The carts' total kinetic energy increases by an amount equal to the PE stored in the compressed spring.
K	Tried to use the elastic collision equations 10.43 (p285). These equations are only valid when one of the objects is initially at rest, which is not the case in this situation.
L	Other partial attempts.
M	No work.

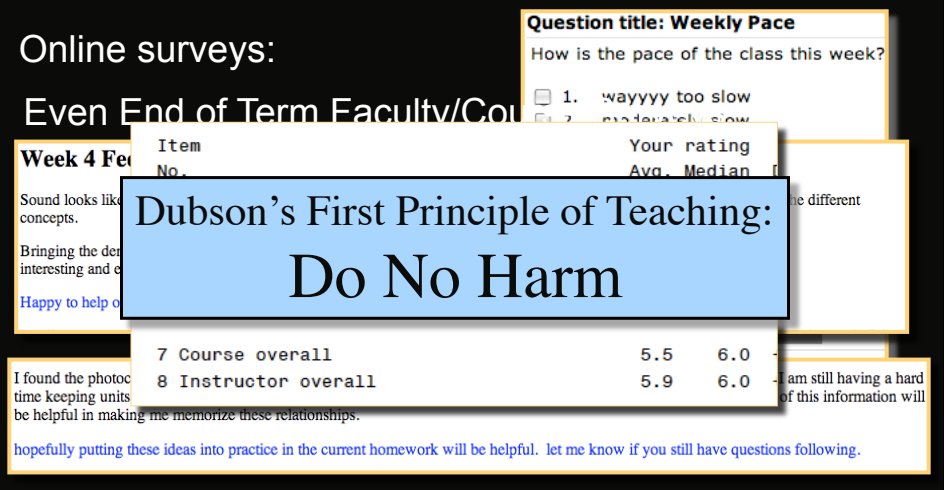
Two Stage Exam
UBC (see: http://www.cwsei.ubc.ca)

1st stage: individual (traditional) - ~66% of time
Turn in
2nd stage: collective response (same exam)
Final score is a mix of both

Categories of Assessments: Listening to Students♪

Online surveys:

Even End of Term Faculty/Cou



A Word about Tenure Matters

Tenure matters
Fuzzy relation between teaching & tenure
Excellence in teaching is critical:
- it matters
- it's moral
- it may be important for promotion
- you will be the ones to establish its value

It is up to you to make the case.
use the assessments to:
- demonstrate scholarship
- improve teaching
- document excellence

Take Home Messages

Sort out What your Goals Are

Find Tools for Evaluating those
flaguide.org, salgsite.org perusersguide.org
www.ncsu.edu/per/TestInfo.html

Listen to your students

Use this feedback to modify and address challenges

You won't get it right the first time--- that's fine.
we're learning too

Don't do everything at once

We're listening & interested

noah.finkelstein@colorado.edu
eprice@csusm.edu

per.colorado.edu
www.colorado.edu/sei
www.compadre.org
perusersguide.org