Improving Student Expectations in a Large Lecture Class

Edward F. Redish
Rebecca Lippmann
University of Maryland

Supported in part by NSF grant REC-008 7519

Learning How to Learn Science: Physics for bioscience majors

- This is a new research grant for the University of Maryland PERG
- Funded by NSF- ROLE (Research on Learning in Education)
- Focus on algebra-based physics
- Supports
  - research into "meta-learning"
  - development of learning environments to help foster meta-learning in College Physics

What is "meta-learning"?

- *Metacognition* — analyzing their own thinking including self-knowledge and assessment and control decisions
- *Epistemology* — what students believe about knowledge and learning
- *Expectations* — what students think is appropriate for a physics course
- *Mental models* — coherent organizational structures providing access to associated knowledge

Personnel: Learning How to Learn Science

- Faculty
  - David Hammer
  - Joe Redish
- Visitors
  - Seth Rosenberg (AY '00-01)
  - Lubna Rana (summer '01)
- Postdocs
  - Andy Elby
  - Laura Lising
  - Rachel Scherr
- Grad Students
  - Rebecca Lippmann
  - Jon Tuminaro
  - Tim McCaskey
  - Paul Gresser
- Undergraduates
  - Leila Malieri
  - Nora McDermott-Taboori (Vassar)

Algebra-Based Physics:

- Environment (2 14 week semesters)
  - Lecture (150 minutes / week)
  - Recitation (50 minutes / week)
  - Lab (110 minutes / week)
  - Partially graded homework each week
- Population Characteristics
  - Predominantly female. (~60%)
  - Completed two semesters of calculus (>95%) but less confident about math than engineers.
  - Mostly biological science majors. (50-80%) (The college of life sciences requires physics.)
  - Not all pre-meds. (~30-40%)
  - Often juniors and seniors. (50-80%)

Some "meta-learning" changes

- Lecture
  - enhanced ILDs
  - focus on problem solving using core (conceptual) equations
  - use of occasional "Elby pairs"
- Tutorial
  - mix of UW-PEG and ABP Tutorials
  - coordinated with lab (traditional)
- Homework
  - fewer, harder, thinking problems
  - context relevant problems
  - regular block office hours

Conceptual Equations

$$\langle v \rangle = \frac{\Delta x}{\Delta t}$$

$$\langle a \rangle = \frac{\Delta v}{\Delta t}$$

- Kinematics are handled with only two equations.
- These equations are related directly to the conceptual ideas.
- Other equations are (always in lecture) obtained from processing these equations.
- If students put in numbers early, intermediate variables appear, and not the traditional equations (e.g., $s = ½ at^2$)

Typical homework problem

- A motion detector measures the time delay for a click to echo and return. The computer uses the speed of sound (~ 330 m/s at room temperature) to calculate the distance to the object.

  The speed of sound changes with temperature. At 72 ºF, v_S ~ 330 m/s. At 62 ºF it is about 1% smaller. Suppose we measure an object 2 m from the motion detector.
  - If T=72 ºF what is the time delay Δt the computer detects before the echo returns?
  - If T= 62 ºF what distance would the computer report?

"Elby pairs"

- Elby introduced a method that carried the cognitive conflict approach a step farther.
- He creates paired questions,
  - one which most students are likely to answer correctly,
  - one which students are likely to answer with a common misconception.
- He then leads them to see there is a contradiction in their thinking and helps them resolve it.
- It sends a different "meta-message"
  - not that "physics is right, your intuition wrong"
  - rather, that "physics helps you resolve contradictions in your intuitions."

Look at the population in 3 ways

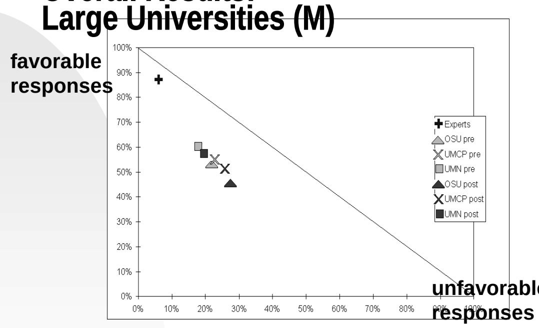
- MPEX pre-post survey (Redish)
- "Fishing expedition" interviews pre-post, our students and from other classes (Lippmann)
- Actual observed behavior in group-learning environments — tutorial and lab (Lising)

The MPEX Survey*

- The goal is to determine the distribution and evolution of students' cognitive attitudes —beliefs that have an effect on what they learn in a physics class.
- The MPEX contains 34 statements with which students are asked to agree or disagree on a 5 point scale.
- The MPEX has been delivered at more than 20 colleges and universities to more than 5000 students.
- It probes independence, coherence, concepts awareness, reality link, and math link.

** E. F. Redish, J. M. Saul, and R. N. Steinberg, Am. J. Phys.* ***66*** *212-224(1998).*

Overall Results: Large Universities (M)



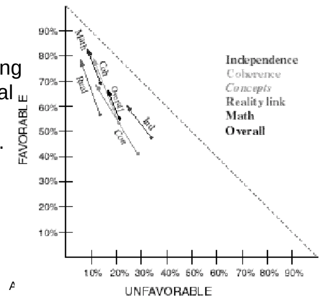
- Introductory mechanics (C) at 3 large research universities: ~500 each
- Initial distribution far from ideal.
- Result of instruction is a loss.

Overall MPEX Results

- In large lecture classes, a semester of physics instruction produces a deterioration.
- This is even true in reformed classes that are successful in producing substantial gains in students' learning of basic concepts.
- Smaller classes where the class focuses on explicit discussion of intuition building can produce substantial improvements.

MPEX Improvements in Elby's Metalearning oriented class

- In his class at TJ HS in Virginia, Andy Elby focused on meta-learning and obtained substantial improvements on the MPEX variables.

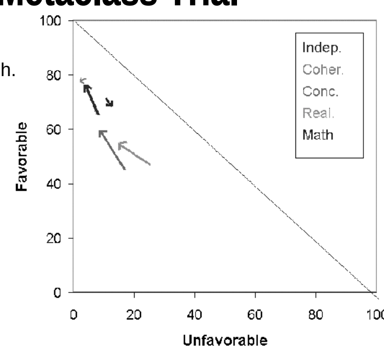


Preliminary Results

- Introducing some of these elements in Fall 2000 (N = 60)
  - ◆ We obtained the largest percentage gains we have ever recorded at Maryland on a standard mechanics conceptual test.
  - ◆ We recorded the first improvement on the MPEX that we have ever obtained in a large lecture class.

MPEX Results in Metaclass Trial

- Coherence and math started high and remained high.
- Strong improvements in independence, coherence, and reality.
- Improvements represent both increases in favorable and decrease in unfavorable responses.



Some notable gains (N = 60; F = disagree)

- "Problem solving" in physics basically means matching problems with facts or equations and then substituting values to get a number. (#4)

	F	N	U
Pre	66%	30%	4%
Post	91%	9%	0%

- My grade in this course is primarily determined by how familiar I am with the material. Insight or creativity has little to do with it. (#13)

Pre	57%	40%	3%
Post	79%	19%	2%

- Learning physics is a matter of acquiring knowledge that is specifically located in the laws, principles, and equations given in class and/or in the textbook. (#14)

Pre	36%	53%	11%
Post	64%	34%	2%

- The most crucial thing in solving a physics problem is finding the right equation to use. (#19)

Pre	45%	45%	10%
Post	72%	26%	2%

Fractional gains on conceptual test of Newtonian mechanics