Improving Student Expectations in a Large Lecture Class

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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

- 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., \( s = \frac{1}{2} at^2 \))

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 °F, \( v_s \approx 330 \text{ m/s} \). At 62 °F it is about 1% smaller. Suppose we measure an object 2 m from the motion detector.
- If \( T=72 \) °F what is the time delay \( \Delta t \) the computer detects before the echo returns?
- If \( T=62 \) °F 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.

Overall Results: Large Universities (M)

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.

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

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