Students' Ideas about Physics: Insights from Physics Education Research

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Who's in the room?

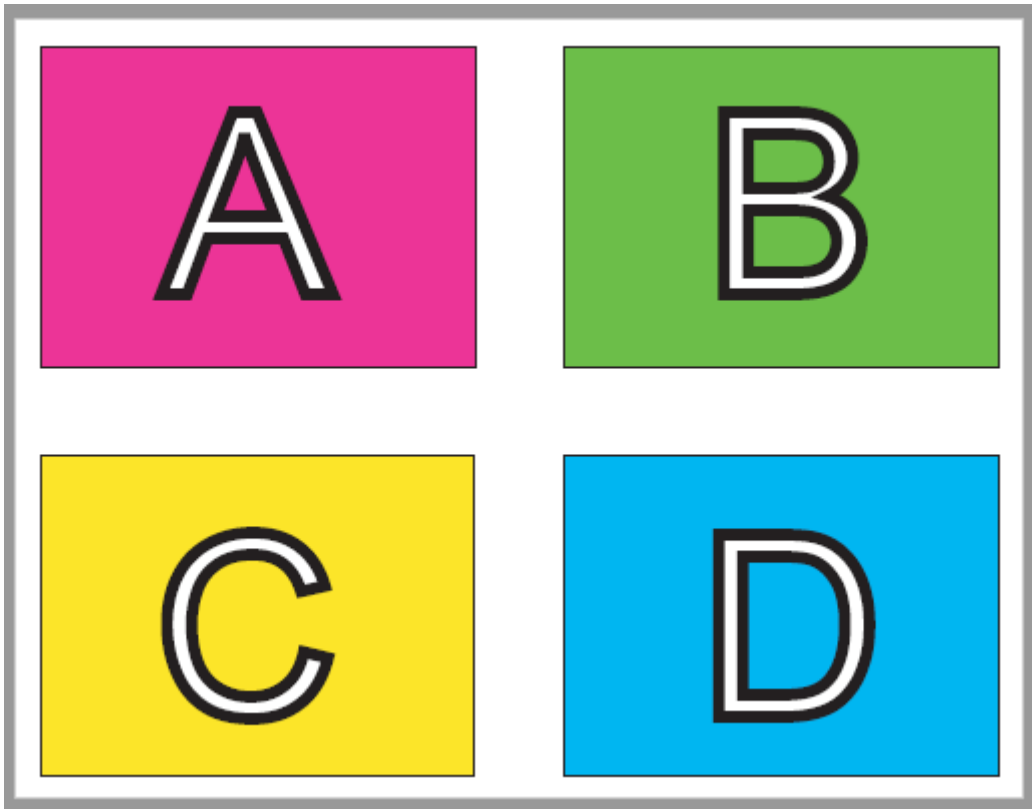
- Physics teachers?
- Chemistry? Biology? General science? Other?
- High school teachers?
- Middle school?
- Elementary school?
- College?
- What else?
- Have you heard of physics education research (PER)?

Goals for this session

- What are our students thinking?
- **Why** are they thinking this?
- What can we do about it?

“Analog clickers”

- Fold your page in half twice



What is the largest island in the Federated States of Micronesia?

A. Kosrae
B. Pohnpei
C. Weno
D. Yap

What is the largest island in the Federated States of Micronesia?

- How did you reason about this question?
- Is this similar to the questions you give your students?
- What is different about how students approach a physics question (that they don't already know how to answer)?

Force Concept Inventory

- Hestenes, Wells, & Swackhamer (1992), *The Physics Teacher* **30**, 141
- 30 multiple-choice conceptual questions on Newtonian mechanics
- Incorrect answer choices are based on research on students' ideas
- Traditionally taught introductory courses show low scores even after instruction (Hake 1998)

Force Concept Inventory

- Answer on your own for each question:
  - How would **YOU** answer it?
  - How would **your students** answer it?
- Discuss in groups
- WHY would your students give this answer? (Explain their reasoning.)
- What aspects of their reasoning are correct? What aspects are incorrect?

Theoretical frameworks

- **Constructivism:** Students are not blank slates. They interpret everything through their existing knowledge.

Theoretical frameworks

- **Misconceptions:** Students have stable beliefs about physics concepts, which differ from expert understanding
  - Identify students' incorrect ideas
  - Confront these ideas directly
- **Resources (knowledge in pieces):** Students' knowledge is dynamic and might be fragmented, with different "resources" that might be activated in different contexts
  - Identify students' resources
  - Help students activate these resources productively

What conceptual resources are students drawing on to answer the car/truck question?

- ???

What **epistemological** resources are students drawing on to answer the car/truck question?

- *Epistemology* = the nature of knowledge
- Physics knowledge comes from authority (textbooks, teachers)
- Physics is a description of what I experience in everyday life
- Physics doesn't have to make sense
- Physics is what can be described by equations
- The physics answer and the common-sense answer should agree

Are students always reconciling physics with their intuitions?

- McCaskey 2009: Gave students the FCI, and asked them to answer “that makes the most intuitive sense to you” and the answer “you think scientists would give”
- After taking physics, students got the right answer that “scientists would give”
- But this wasn’t what made intuitive sense to them!

Refining intuitions

- Elby, Helping physics students learn how to learn, *Am. J. Phys.* **69,** S54 (2001)
- Raw intuition: The car reacts more than the truck.
- Refined intuition: The car experiences more **acceleration** than the truck.
- $F = ma = ma$

Students' conceptual resources for energy

- Sabo, Goodhew, & Robertson, University student conceptual resources for understanding energy, *Phys. Rev. PER* **12**, 010126 (2016)
- Try the Emily question in groups.
- What conceptual resources would you want to see students use to answer this?

Students' conceptual resources for energy

- What the researchers found:
- Track energy as it moves through a system
- Associate forms with indicators or changes in energy with indicators of change
- Recognize that energy transfers at contact
- Implicitly use the second law of thermodynamics (Acknowledge that energy flows from hot to cold until thermal equilibrium is reached)
- Quantify relative amounts of energy

Students' conceptual resources about energy

- Now what?
- How do we help students build on these resources?

General discussion