Epistemologies in Physics

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What is epistemology?

- Theory of knowledge, especially with regard to its method, validity and scope. It is the investigation of what distinguishes justified belief from opinion.

- Essentially, a student’s view about the nature of knowledge and learning.
Curricular Developments

Traditional Method: Lectures

Workshop Physics

- Many colleges use a workshop physics approach
- Based on group work, peer sharing

Modeling Physics

- Formulas and concepts derived from labs
- Based on first-hand experience, group work, peer sharing

Aimed at content understanding, improving epistemological beliefs
How do we measure students’ epistemologies?

- MPEX (Maryland Physics Expectation Survey)
- Responses of students compared to those of experts (professors)
- across institutions
- at the beginning and the end of one semester of instruction
What does MPEX look like?

- Independence – beliefs about learning physics
- Coherence – beliefs about the structure of physics knowledge
- Concepts – beliefs about the content of physics knowledge
- Reality Link – beliefs about the connection between physics and reality
- Math Link – beliefs about the role of mathematics in learning physics
- Effort – beliefs about the kind of activities and work necessary to make sense out of physics
What does MPEX look like?

All I need to do to understand most of the basic ideas in this course is just read the text, work most of the problems, and/or pay close attention in class.

If I came up with two different approaches to a problem and they gave different answers, I would not worry about it; I would just choose the answer that seemed most reasonable.

“Problem solving” in physics basically means matching problems with facts or equations and then substituting values to get a number.
And the survey says...

- Overall results deteriorated at every school as a result of one semester of instruction.
- Effort - students put in less effort than they first thought they would.
- Independence - half the schools.
- Coherence - two-thirds of the schools.
- Math Link - half the schools (other half showed no gain).
- Reality Link - ALL of the schools.
Einstein said...

“The whole of science is nothing more than a refinement of everyday thinking. It is for this reason that the critical thinking of the physicist cannot possibly be restricted to the examination of concepts from his one specific field. He cannot proceed without considering critically a much more difficult problem, the problem of analyzing the nature of everyday thinking.” (1936)
How does this apply to the classroom?

- New curricular methods improve conceptual learning as measured by Force Concept Inventory - students can engage in productive learning w/o reflection

- Possible to embed epistemological material in labs and homework assignments

- Oftentimes amount of content covered suffers due to added time of addressing epistemologies
Essentials to an epistemologically friendly classroom

- Emphasize explanation over plug ‘n’ chug problems
- Effort based homework grading versus just getting the “right” answer
- Metacognitive behaviors, Illuminating the “hidden curriculum”
- Reduce reliance on traditional textbooks
- Reduce content coverage
- Improve teacher preparation
How does this apply to High School physics?

- Reduced content coverage in favor of deeper understanding
- Hands-on and Heads-on physics (interactive!)
- Necessary preparations to help teachers carry out an epistemologically focused curriculum
- Reflection time
How does this apply to College or University physics?

- Reduced content coverage?
- Lab sections focusing on epistemology – teaching students how to learn physics, “writing” homework assignments
- Homework assignments focusing not just on numerical solutions
- Create new course similar to one at UMD – “How to Learn Physics”
Newton’s 2nd Law Lab

A car cruises steadily down the highway at 60mph. Wind resistance opposes the car’s motion with a force of 5000N. Intuitively is the forward force on the car less than 5000N, equal to 5000N or greater than 5000N? Explain.

In this question we’ll see if N2L agrees with your intuitive guess.

When the car cruises at constant speed 60mph, what is its acceleration, \( a \)? Explain your answer briefly.

Therefore, according to \( F_{\text{net}} = ma \), when the car moves at constant velocity, what net force does it feel?

So, is the forward force great than, less than, or equal to the 5000N backward force? Does this agree with your intuitive answer to question 1?

Ok, here’s the punch line. Most people have the intuition that, if an object is moving forward, there must be a (net) forward force. Explain in what sense that intuition is helpful and correct, and in what sense that intuition might seem misleading.


• Edward Redish and David Hammer, “Reinventing College Physics for Biologists: Explicating and epistemological curriculum,” 2009


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