The importance of epistemological considerations in fostering conceptual development

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Introduction to epistemology

Epistemological stance =
Views about the nature of knowledge & learning

Unproductive	*Productive*
Physics knowledge = disconnected facts/formulas	Physics knowledge = connected concepts
Mostly memorization	Building ideas
Common sense plays little role in learning physics.	Learning physics involves refining everyday thinking.

Clarification: Public vs. personal

- Personal epistemology = Views about one's own knowing & learning
  - Examples on previous slide
- Public epistemology = Views about the nature of discovery and Knowledge in the scientific community
  - Absolute & certain vs. Evolving & contingent
  - Relationships between observations, hypotheses, theories

How can we describe student epistemologies?

- Results
  - Interviews reveal shades of gray.
    - Some students see concepts primarily as rough cues for which formulas to use (Hammer).
    - Some students see physics concepts as potentially coherent to physicists but not to students (Hammer).
  - Certain naïve epistemological views are prevalent.
    - Formulas carry little meaning; personal experiences and intuitions aren't relevant; … (MPEX, VASS).

Epistemology research questions

Epistemological change: How does instruction affect student epistemologies?

- Results
  - Traditional instruction: x
  - PER-based curricula targeting concepts: x
  - Some PER-based curricula with explicit, course-suffusing epistemological focus: þ
- Open issues
  - How do students engage in active learning without adopting a more "active-learning" epistemology?
  - What brings about epistemological change?

Epistemology research questions

Interface: How does a student's epistemology affect conceptual learning?

- Results
  - Epistemology correlates w/ learning outcomes…
    - …even when controlling for confounding factors. (Schommer et al.)
    - …in conceptually-oriented physics courses (Elby; Redish; May; White)
  - Wisps of causal mechanism
    - Belief that natural ability determines learning skill → less effort (Dweck)
    - View of physics knowledge as coherent → self-initiated searches for connections (Hammer)

Epistemology research questions

Interface: How does a student's epistemology affect conceptual learning?

- Open issues
  - We need fine-grained causal stories of epistemology affecting conceptual learning...
    - …to build a deeper understanding of student epistemologies.
    - …as a guide to revising curricula.

OUR MAIN POINT

for curriculum developers & adapters focused on *conceptual* change

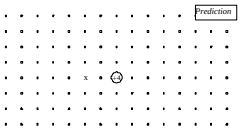
Even if epistemology isn't our main concern, we benefit from attending to epistemology when studying students' interactions with our materials and when revising those materials.

Evidence for main point

- Video of 4 students
  - U.Wa. electrostatics tutorials severely rewritten and condensed by U.Md. to fit into limited time

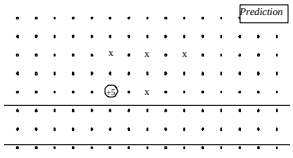
What happened before the clip?

- Intro to electric field
  - Draw vector showing force on test charge q = +1.
  - How does force change if q = +2? q = +3?
  - Compare the ratio of force to q in the three cases.
  - [Define E-field as that ratio.]
  - Does E-field strength depend on size of test charge used to measure it?



The question they're addressing

- Strength of E-field due to single source charge
  - Draw vectors showing the electric field at each point marked by x.



QuickTime™ and a
Cinepak decompressor
are needed to see this picture.

Insights from snippet relevant to the curriculum developers

- Students 1 and 2 begin in qualitative sense-making mode.
- After student 3 knocks them into mathematical sense-making mode, students 1 & 2 stay there.
- It's not clear if students 1 and 2 hook up their qualitative intuitions to the math.
- Student 3 never enters into qualitative sense-making mode.

Possible tutorial revisions

- Strength of E-field due to single charge
  - Using common-sense reasoning with no formulas, draw arrows representing the electric field at each point marked x.
  - Do your answers agree with the mathematical definition of electric field from part 1? Explain in detail. If needed, reconcile your qualitative and quantitative reasoning.

Conclusion

Attending to *epistemological* considerations gave us ideas about making the tutorial a better environment for *conceptual* development.