The importance of epistemological considerations in fostering conceptual development

Andy Elby & Laura Lising
University of Maryland, College Park

Introduction to epistemology

Epistemological stance = Views about the nature of knowledge & learning

<table>
<thead>
<tr>
<th>Unproductive</th>
<th>Productive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physics knowledge = disconnected facts/formulas</td>
<td>Physics knowledge = connected concepts</td>
</tr>
<tr>
<td>Mostly memorization</td>
<td>Building ideas</td>
</tr>
<tr>
<td>Common sense plays little role in learning physics.</td>
<td>Learning physics involves refining everyday thinking.</td>
</tr>
</tbody>
</table>

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.

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**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.

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**Evidence for main point**

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

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**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?

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**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 \( x \).
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.