Bringing Epistemological Considerations to Tutorial Design

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Main points

🌟 *Show ‘n’ tell*: Tutorial that focuses on the nature of understanding and doing physics.
  – Topic: Free-body diagrams (FBDs).

🌟 *Case study*: How one student’s view of FBDs “evolves” during the tutorial.
Motivation

✱ Tutorials & most other PER-based curricula…
  – Don’t produce epistemological gains (MPEX), but,
  – Produce good conceptual gains.

So why worry about epistemology?

  – Learning about learning can help students thrive in later courses.
  – Understanding various concepts alone does not lead to a coherent, sense-making approach to problem-solving. (Kanim, AAPT PERC 2001).
Specific motivation behind our second FBD tutorial

★ Students don’t use FBDs as a sense-making tool.
  – Drawn only on demand, or as part of a recipe.
  – When demanded, not incorporated into reasoning.

★ Epistemological component of these deficiencies:
  – Only weak connections (not strong coherence) seen between representations, concepts, and problem-solving.
    --> FBD viewed as a product, not a reasoning tool.
Strategy for addressing the red epistemological issue

**Prime students to think about the issue:** Are FBDs sense-making tools for students or answers created for teachers, or both?

**Activate productive sense-making resources:** Students “discover” usefulness of FBDs.

**Articulate & reflect upon those resources.**
FBD tutorial: Part II

Preamble: Box B punctured if it feels a >200 N force.

B1) Is the 200 newton push force “transmitted” to box B? … Does the box puncture? Don’t do any calculations; answer intuitively, and explain your thinking.
QuickTime™ and a Cinepak decompressor are needed to see this picture.
Analysis of student’s response

Doesn’t think intuitions or sense-making apply here.

--> No reason to draw FBD as sense-making tool.
Tutorial leads students through explanation of why B feels a force less than 200 N.

– Key point: Keeping track of which forces act on which objects.
FBD tutorial: Part II, continued

D1) Draw separate free-body diagrams for boxes A and B…

D2) A group of students is discussing whether to label the force on block B as $F_A$ on $B$ or $F_{\text{student}}$ on $B$. One student states,

“The rule says you’re supposed to label it $F_A$ on $B$. But this is one of those rules that’s an arbitrary choice, like the rule that red means stop and green means go. Breaking this rule wouldn’t actually mislead you when you’re solving a problem.”

Do you agree that the rule is an arbitrary choice, or do you think there is some kind of deeper reason behind it? Explain.
QuickTime™ and a Cinepak decompressor are needed to see this picture.
Analysis of student’s response

★ Sees the FBD labeling rule as connected to sense-making.

– Doing it the other way “wouldn’t have made as much sense…”

– Particularly helpful for 3rd-law pairs.
D4) In this situation, does drawing the free-body diagrams help you to think about a specific problem (such as the box-puncturing question), or is it just to help you and/or the TA see if you know what forces are present?
B1) ….Would you guess that crate 3 pushes back against crate 2 with a force that is greater than, less than, or equal to 10 newtons [the frictional force felt by Crate 3]? Explain your idea.
QuickTime™ and a Cinepak decompressor are needed to see this picture.
Tutorial homework

*Epistemological goal:* Crystallize students’ contextually-activated resources into conscious beliefs, via articulation & reflection.

– *Example: Homework question II.*

In tutorial, there were some situations in which it wasn’t really necessary to draw free-body diagrams. In the particular problem you just addressed (problem I), was it helpful for your reasoning – or would it have been helpful for your reasoning – to draw free-body diagrams? Explain why or why not.
Conclusion

★ Local: Reflecting upon their experiences using FBDs as sense-making tools nudges some students toward a “better” view of FBDs.
  – Most common responses to homework question II:
    • Sort out 3rd law pairs, keep track of which forces act on which objects. (~40%)
    • Visualize (~30%)

★ Global: It’s possible to build an epistemological agenda into a content-centered tutorial.