Challenges and possibilities of meaningful assessment in introductory STEM

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This seminar is based on projects funded by the National Science Foundation. It doesn’t necessarily support these ideas, but it should.

Problem: Find the acceleration of the masses

Roger and Tony each found the total force:

\[ F_t = m_1 g - m_2 g \sin \theta \]

then set

\[ F_t = m_1 a \] and \[ F_t = m_2 a \]

which led to \[ a_1 \neq a_2 \]

Roger's response

From what I put, I guess that's right... Oh geez, how could one be accelerating faster than the other... that would mean the velocities would have to be different... yeah, I guess so... Well, I don't know, I'd check, and see if I got the right answer. I'm 90% sure.

Tony's response

The acceleration here can't be higher... they have to move at the same speed.

Before I said that this force was going to be... right here, and now I'm saying that's not true. And actually, now that I think about it that is right. 'cause this force is accelerating more than just this box, it's also accelerating this box... the force isn't going to be equal, the accelerations are... ok, that's what it is.

Students learn how to assess ideas as part of learning science.

Roger: “Does the answer agree with the key in the back of the book?”
Tony: “Does the answer make sense? Does it fit with what I know?”

We need assessment practices that

- model and encourage practices of assessment in science,
- evaluate their taking up those practices, as well as their understanding of target ideas.

It’s challenging...

- Students come in with expectations for how we will (and they should) assess their work.
- It’s much easier and more “objective” to check their answers for consistency with the canon than to assess the sense of their thinking on its own terms, as nascent science.

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...and it’s humbling.

Some elements of course design

- Interactive lectures (clickers and conversation)
  - conceptual questions
  - discussion of epistemology
- Open-ended labs
  - How closely can we know by measurement the time it takes for an object to fall 2 meters? (a new idea)
  - Measure the speed of a ball at the bottom of a ramp, and decide if it matches theory. (asked before discussion of rotational energy)
- Fewer but harder problems for homework
  - Evaluated mainly for “honest effort”

Redish & Hammer, 2009
Lectures as conversations, to cultivate...

- Explaining in plain language “for 10 year old”
- Looking for and trying to address possible counter-arguments
- Meaningful questioning (student questions often become clicker questions)
- Responsiveness to substance

Swinging a ball in a vertical circle

Which expression makes sense at the bottom of the motion?

1. $T + mg = \frac{mv^2}{r}$
2. $T = \frac{mg}{r}$
3. $mg = \frac{mv^2}{r}$
4. I'm not sure
5. I haven't covered this!

Most chose B, and we've just discussed.

Assessing their progress

- Some beginnings
  - A student’s question
  - Attention to coherence
  - Drawing implications from clear ideas
  - Nalani’s, others’ surprise at classmates’ reasoning

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Still...

- Mapping uncritically to remembered cases
- Inattention to coherence (scientific coherence)
- Mostly trying to “Get it right”
clip 2, three weeks later

We’ve worked it out that $m_x = 2 m_y$. Xena pulls on the rope so that they move toward each other. About where do they meet?

Bian: In these types of problems they always say the mass of the rope doesn’t matter. Why would the mass of the rope make a difference?

David: Right. I’m trying to make a similar question out of that.

Assessing their progress

• students’ questions
  how would mass make a difference, what if Yara?
  
  Reasoning across situations
  
  Tangible, sensible reasoning
  not as much force gets to Yara

Invention

think of half the rope with X and half with Y

clip 3, near end of course

Homework assignment they just handed in.

Most say the block wins.
A 2 kg block sits on a cart of mass 8 kg. The cart is accelerating to the right at 2 m/s², and the block accelerates with it, without slipping. The coefficient of static friction between the block and cart is \( \mu_s = 0.3 \).

What is the size and direction of the friction force on the block by the cart?

1. 6 N to the left
2. 6 N to the right
3. 4 N to the left
4. 4 N to the right
5. I don't know.
Suppose instead of pushing on the 8 kg cart, you push on the 2 kg block. For example, you could pull it with a rope, as I've shown.

What would be the maximum force in that case, that you could exert on the 2 kg block without it slipping? As before, assume there's no friction between the 8 kg cart and the surface it's on.

a) Give a sensible argument for the answer you believe.

b) Give a sensible argument for an answer you think someone else might believe.

c) Try to explain the flaw in the reasoning for part b.
Assessment

Students’, of the quality of ideas
- Can we explain it in simple terms?
- Does it make sense?
- Can we respond to conflicting arguments?

The instructors’ of students’
- understanding
- approaches to learning

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Of the class as a whole, as well as of individuals

TA attention and response to student reasoning in written work

Cynthia Hill
Tufts University
3rd Annual STEM presentation day

TA attendance and response to student reasoning in written work

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Methods: coding written feedback

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TAs attended mainly to style & form

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