Student epistemic framings for a conceptual physics test question

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Introduction

Epistmemic beliefs are an important facet of student development and success in introductory physics [1, 2]. Epistemic flexibility in problem solving is a hallmark of the development of expertise [3]. But are sophisticated and flexible epistemic beliefs being developed through assessments?

As any professor who has been asked "Will this be on the test?" knows, tests are the primary focus of many students. Though physics educators might try to develop mature epistemic beliefs in their students, many students only see value in what will help them succeed on assessments [4].

Therefore, this study seeks to better understand how students make sense of physics exams and problems. The work is guided by two research questions:

Q1. How do physics students' framings of exams affect their responses to exam questions?

Q2. What epistemic resources do students use when attempting to solve a question without a numeric or symbolic answer?

Here the term "framing" is defined by as the answer to the question, "what kind of activity is going on here?" [5].

Data Sources

- Student answers on a test question
- Post-test reflection essays

  Students were asked about what methods they used to try to solve the problem and, if they conceptually knew the answer, what were their reasons for questioning their conceptual understanding.
- Population: 13 students in a calculus-based, introductory physics course

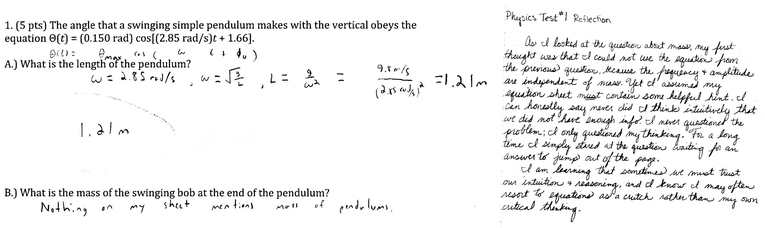
The Test Question

The angle that a swinging, simple pendulum makes with the vertical obeys the equation $\Theta(t) = (0.150rad)\cos[(2.85rad/s)t + 1.66]$

A.) What is the length of the pendulum?

B.) What is the mass of the swinging bob at the end of the pendulum?

Unfortunately, the students struggled with the fact that no numeric or symbolic solution existed to part B. Though most would have probably gotten the question correct in the multiple choice format, only three did in this scenario.


1. (5 pts) The angle that a swinging simple pendulum makes with the vertical obeys the equation Θ(t) = (0.150 rad) cos[(2.85 rad/s)t + 1.66].

A.) What is the length of the pendulum?

$\omega = 2.85$ rad/s, $\omega = \sqrt{\frac{g}{L}}$, $L = \frac{g}{\omega^2} = \frac{9.8\ m/s}{(2.85\ rad/s)^2} = 1.21$ m

1.21 m

B.) What is the mass of the swinging bob at the end of the pendulum?

Nothing on my sheet mentions mass of pendulums.

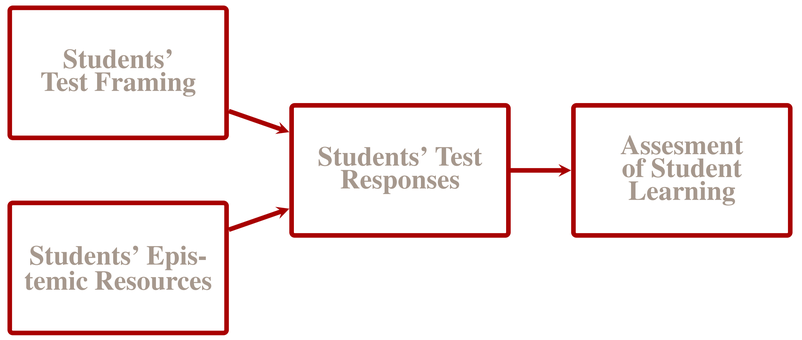
Physics Test #1 Reflection

As I looked at the question about mass, my first thought was that I could not use the equation from the previous question, because the frequency + amplitude are independent of mass. Yet I assumed my equation sheet must contain some helpful hint. I can honestly say never did I think intuitively that we did not have enough info. I never questioned the problem; I only questioned my thinking. For a long time I simply stared at the question waiting for an answer to jump out of the page.

I am learning that sometimes we must trust our intuition + reasoning, and I know I may often resort to equations as a crutch rather than my own critical thinking.

"Although I did know that the period [of the pendulum] is independent of the mass. . . I figured that since it was a short answer question, there had to be a way to calculate mass. The fact that I assumed we wouldn't be given a question incapable of being solved, I didn't give up on the problem until I had a numerical answer."

— Jackie



Epistemic Resource Framework

The student reflections were analyzed using a set of preexisting codes while also allowing for emergent codes. The preexisting codes corresponded to four epistemic resources [5].

Calculation: "Algorithmically following a set of established computational steps should lead to a trustable result."

Physical Mapping: "A mathematical symbolic representation faithfully characterizes some feature of the physical or geometric system it is intended to represent."

Invoking Authority: "Information that comes from an authoritative source can be trusted."

Math Consistency: "Mathematics and mathematical manipulations have a regularity and reliability and are consistent across different situations."

"I recall looking through my theorem sheet, looking for equations for pendulums that involved mass. When I couldn't find any equations, I began trying to manipulate equations in efforts to re-write them in terms of mass."

— Helen

Results

Test Framing

The following test framing codes emerged:

- Test questions have a numeric or symbolic solution.
- Test questions always have one right answer.
- Short answer test questions always have enough information to find a numerical solution.
- Test questions use equations from the equation sheet.

Resource Use

- Every student invoked at least one of two types of authority.
  1. Equation sheet
  2. Class related authority
- Invoking authority was usually followed by a calculation.
- A math consistency resource was rarely used and was difficult to separate from a calculation.
- Physical mapping was rarely used.

My initial plan was to use my equation sheet [to] find an equation linking mass and length.

— Ulysses

My first thought went back to the lab that we did at the beginning of the semester with the pendulum. During that experiment, we were told the mass was not relevant and that was my first clue that the answer to this problem might not be numerical.

— Julia

Conclusions and Future Work

Most students failed to successfully answer the problem because their framings of a physics test failed to account for a short answer question without a numeric or symbolic answer. They expected that any other answer would be explicitly suggested by multiple-choice options or legitimized by the instructor.

The data also showed that students primarily focused on invoking authority and calculations as their epistemic resources. This is not surprising as student expectations for exams are that solutions are normally numeric or symbolic.

Originally, I wrote. . . "the motion of a simple pendulum is independent of mass." However, I changed my answer because "you can't" is never an acceptable answer on a test. . . I wasn't confident enough to say, "there is no way to do this" because usually if that is an acceptable answer, that is explicitly stated either in the directions or by the professor.

— Hannah

We see potential for future work in the following areas:

- deliberate focus on student framings of physics tests and other formal and high-stakes assessments
- comparison of student reflections on problem solving and conceptual understanding to quantitative measures of conceptual understanding
- connection of the epistemic resource framework with metacognition and self-regulation frameworks

Acknowledgments

The authors would like to thank the physics students who were kind enough to write reflections about their experiences on this problem. Despite their unhappiness about being "tricked," they wrote interesting comments that gave valuable insight into their thought patterns.

Tyler Scott would also like to thank the American Association of Physics teachers for the support they provided to assist him in attending the AAPT meeting and Physics Education Research Conference.

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