

Evidence Of Epistemological Framing In Survey Question Misinterpretation

Paul Hutchison* and Andrew Elby[§]

*Dept. of Education, Grinnell College, Grinnell, IA 50122

[§] Dept. of Teaching, Learning, Policy, and Leadership, University of Maryland, College Park, MD 20742

Abstract. Physics students' views about what kinds of learning and knowledge-generating activities are expected in class, their epistemological framing, influences their reasoning and what they learn. [1,2] In previous work, we observed that students' likelihood of correctly answering a kinematics question easily solved through common sense depended on whether preceding questions on the survey were designed to prime "sense-making" or schoolish "answer-making". [3] To get insight into students' reasoning we collected 24 think-alouds. [4] The think-aloud data indicate that some participants who incorrectly answered the question misinterpreted the physical situation it describes. On its face this observation might be seen as evidence that inferring answer-making from an incorrect answer lacks validity. However, analysis indicates that students misinterpret the question because of how they frame their approach to answering it. So, misinterpretation of the kinematics question is a signal of epistemological framing, not an impediment to seeing it.

Keywords: Epistemology, framing, think aloud, psychometric validity.

PACS: 01.40.Fk, 01.40.gf, 01.40.Ha

INTRODUCTION

As instructors, we notice many of our students behave as if common sense ideas about the physical world have no role to play in learning physics. We don't blame students for this, since it is likely a reasonable response to their previous science instruction. But it needs to be addressed. We and others have used the following question (Fig. 1) as a way to spark discussion about this issue with our students:

Two baseball pitchers each throw a baseball. They let go of the balls at the same time from the same height. The only difference is that one pitcher throws his ball straight down and the other pitcher throws his ball horizontally. Which ball will hit the ground first?

- A) The ball thrown horizontally
- B) The ball thrown straight down
- C) They hit at the same time

Why do you think that's the best choice?

FIGURE 1: The Two-Thrown-Balls Question

Of course, it is common sense—and also physics—that the ball thrown straight down hits the ground first. In classes we know of, though, about 40% of students say the two balls hit at the same time. When we ask those same students how a third grader would respond, almost all say the third grader would think the ball thrown straight down hits first. Because many students answer incorrectly even though they

have a correct intuitive sense of what happens, this question can serve as a “detector” for whether students are using their common sense about the physical world.

The first author previously reported a large n study to see if introductory physics students could be primed to approach the two-thrown-balls question in two different ways: using common sense along with other resources to make sense of the physical world (what we called “sense-making”) versus taking a more “schoolish” approach in which the answer is not expected to cohere with their everyday thinking and experience (“answer-making”) [3]. In the sense-making priming condition, students first answered three science questions intended to elicit everyday/intuitive reasoning, and then they answered the two-thrown-balls question. For example, one of the priming questions asked whether a Styrofoam cup or a ceramic mug would keep hot coffee warmer. In the answer-making priming condition, students answered three typical physics class problems before answering the two-thrown-balls question. The study confirmed our hypothesis that students were significantly more likely to answer the thrown balls question correctly when sense-making was primed than when answer-making was primed. In a section of 127 participants, 77% of those assigned to the sense-making condition answered correctly while only 61% of those in the answer-making condition did so.

Our interpretation of what these results mean relies on plausible assumptions about what correct and

incorrect answers to the two-thrown-balls question indicate. Having demonstrated that we could produce systematic differences across conditions, we conducted a think-aloud study to determine why students answered the two-thrown-balls question as they did. We were concerned, in part, that participants might misinterpret the two-thrown-balls question as asking about one horizontally thrown ball and one ball dropped from rest—a scenario commonly explored in physics courses to illustrate the independence of the vertical and horizontal components of motion—rather than two thrown balls. The problem statement intends to communicate that both balls have a non-zero initial velocity. The term “throw” is used to communicate this. It appears three times in the problem, once referring to the action on both balls (“Two baseball pitchers each throw a baseball.”) and then twice more referring to the action on each individual ball. (“The only difference is that one pitcher throws his ball straight down and the other pitcher throws his ball horizontally.”) But despite our efforts at clarity, if participants misinterpret the question as the “drop versus horizontal throw” scenario, the psychometric validity of our inference and the utility of the survey instrument are threatened [5].

This paper reports one aspect of our results from the think-aloud study. A few participants did indeed misinterpret the question as the drop vs. horizontal throw situation and gave an incorrect answer as a consequence. However, the misinterpretation did not stem from a careless or quick reading of the question. Participants who misinterpreted or considered the misinterpretation did something to check their interpretation, such as rereading the question. We will argue below that misinterpretation stemmed in part from participants’ framing their activity as answer-making, viewing the task as schoolish activity disconnected from common sense. Hence, question misinterpretation is a signal of what we are looking for, not an impediment to seeing framing and so not a threat to validity.

METHODS

Theoretical Framework

Our methods reflect our “resources and framing” theoretical framework, according to which individuals do not hold context-independent epistemological beliefs, but rather, have multiple stances toward knowledge and learning available to them. How an individual *epistemologically frames* a given activity—her view of “what is it that’s going on here” [6-7] with respect to knowledge—can depend on numerous contextual cues in interaction with her prior history as

a learner and knower [1-2, 8]. In this work we use the labels *answer-making* and *sense-making* to refer to two common ways learners can frame knowledge-related activity in school science. Answer-making refers to a view that producing an answer involves using teacher- or textbook-sanctioned methods, usually a formula or a rule in introductory physics, to generate an answer that “counts” in a school setting. Sense-making refers to a view that producing an answer draws on ideas from a broader set of the learner’s experiences. While this includes drawing on ideas that make intuitive sense, ideally it also includes school ideas and leads to reconciling in moments of inconsistency.

Data Collection

We interviewed twenty-four participants using a think-aloud protocol [4]. Sixteen came from first-semester introductory physics courses at two different colleges. Eight college students who had not taken physics in college and were not science majors were also recruited from students engaged in summer research projects at one of the colleges.

Physics class participants were randomly assigned to either the answer-making priming or sense-making priming condition. We modified the large n study survey slightly by removing one of the priming questions in each condition, so the two-thrown-balls question was preceded by two rather than three priming questions. Participants first completed two warm-up exercises designed to get them comfortable reporting their thinking aloud. Then they thought aloud while completing their assigned survey. Both versions of the survey end with the two-thrown-balls question as depicted in Fig. 1. A researcher was present for data collection but spoke only to prompt the participant to “please keep talking” if they lapsed into silence for a few seconds. The protocol was the same for non-science participants. However, only the sense-making priming version of the survey was used because the answer-making priming version required familiarity with physics class concepts and methods.

Analysis

The think-aloud interviews were videotaped and transcribed. The relevant data for this paper was participants’ thinking during the two-thrown-balls question. For each answer, we characterized (i) whether the participant showed evidence of misinterpreting the question, and (ii) whether they were using everyday/intuitive knowledge, classroom/textbook knowledge, or both. Our analysis relied primarily on the transcripts, but we viewed videos when we felt they might provide useful insight.

RESULTS & DISCUSSION

Of the sixteen participants drawn from introductory physics classes, six answered that the two thrown balls hit at the same time—three of eight in each priming condition. The ten others answered the question correctly. In the aggregate these are similar to the percentages observed in the large n study, suggesting the difference in data collection setting did not significantly impact participant reasoning. We do not see a greater percentage of wrong answers from participants in the answer-making priming condition, like we got the large n study; but that is not surprising or noteworthy given the low n of each condition.

Of the six participants who answered that the balls hit at the same time, two clearly misinterpreted the scenario as a ball released from rest vs. one thrown horizontally. Also, two other physics class participants asked the interviewer whether the vertical ball was thrown or dropped, indicating that they considered misinterpreting the situation. In both of those cases the interviewer asked them to look at the question again, and when they did so they interpreted and answered it correctly without further researcher participation.

In the analysis that follows we focus on the epistemological frames actually exhibited by the participants when answering the two-thrown-balls question, which is more relevant to our argument than the epistemological frames we were trying to prime.

The misinterpretation by the two participants, Leona and Rachel, is notable, because it was *not* due to inattention or quick, unreflective pattern matching to a familiar scenario. Both made a point to re-read parts of the question to check their interpretation. However, as we now argue, they re-read selectively, in a way that indicates “answer-making” expectations [9] about the problem-solving situation.

After reading the question aloud Leona described her reasoning:

I believe they hit (pause) at the same time. (pause) Oh wait, no hold on. (Rereading question) Same instant from the same height above the ground. (pause) Ok it doesn't say anything about “velocity”. (pause) It says they “let go of” the ball (pause) if they go from the same place at the same time. Same height. Same speed. (Writing) The balls should hit at the same time because the y-component of (pause) the movement is the same, (pause) which would be acceleration due to gravity. But, only because there's no velocity because if there was velocity, that would change.

Leona's initial reaction that the balls hit at the same time may indicate she has already misinterpreted the

question. Apparently seeking to check her interpretation she rereads, looking for the term “velocity” as reasonable evidence. Not seeing “velocity” she attends to the phrase “...let go of...” which is ambiguous with respect to initial velocity, though by itself this does usually mean to release with no initial velocity. Notably she pays no attention to the three instances of the word “throw”, which does connote an initial velocity.

Rachel's think aloud talk is longer than Leona's, so we provide some description and relevant excerpts. Rachel expresses no immediate intuitive answer. She gives voice to an internal debate about whether or not the ball moving straight down has an initial downward velocity. Like Leona, she may not initially notice the word “throw” in the problem statement. For example early in her internal debate she states:

It doesn't actually say if the guy throws the ball straight down, or just drops it. Hm. Because, like, that would make a difference.

As we noted in the Introduction, the term “throw” appears three times in the problem and twice refers to the ball she's thinking about. Rachel began by reading the question aloud prior to giving voice to her thinking, so we know she read the word throw. Later, as she resolves her debate, Rachel uses the term “throw” in a surprising way:

Um (pause) but the guy throwing it downward (pause) Um, I don't know. It doesn't say if he gives it any initial velocity, so (Pause) I'm gonna, I'm gonna assume that he doesn't, because, I don't know, one has to assume these things, so...

Here, her use of the phrase “the guy throwing it downward” suggests Rachel has noticed the term “throw” in the problem statement; but for her, in that moment, “throw” does not imply giving the ball an initial velocity. Note that in the first excerpt Rachel explicitly contrasts “throw[ing] the ball straight down” with “just drop[ping] it.” In that earlier moment, “throw” *did* imply an initial velocity.

What we see in the statements from these two participants who ultimately misinterpret the question is evidence of their expectations about which kinds of words in the question warrant their attention. This selective attention provides insight into their epistemological framing of the activity. Science class words are valued over common, everyday ones as they try to interpret the physical situation the problem describes. Leona, scanning the problem for “velocity,” does not focus on a colloquial term (“throw”) that implies the imparting of a velocity. The repeated use of “throw” in the problem, which she reads aloud when she reads through the problem, does

not register. While we lack insight into why she ends up focusing on “let go of” instead of “throw,” our point is that she does not systematically make meaning of all the potentially-helpful colloquial terms in the problem statement. Similarly, Rachel does not interpret the word throw in the problem statement to mean the pitcher gives the ball an initial downward velocity, even though that meaning of “throw” is clear to her as evidenced by her use of it in the first excerpt.

What we see here is evidence that the participants’ epistemological framing leads them to seek out physics ideas and words. This happens at the expense of everyday/intuitive words that could be interpreted to express the meaning they were looking for. It seems virtually certain that in other contexts both participants know “throw a ball” means to let it go with some initial velocity as it leaves your hand. However in this context, in the way they frame their answer production, “throw” is either not attended to or is stripped of its colloquial meaning.

Rachel gives us further indication of this framing early on in her response when, after drawing a diagram of the situation, she says:

Okay, this is pretty simple, it's like, the thing we were talking about in physics with like, um (pause) vectors and motion.

Here Rachel explicitly connects her reasoning to words from her physics class. In and of itself this is not strong evidence that for her, physics class problems elicit what we call answer-making. But when combined with her later misinterpretation of the problem based on ignoring the colloquial meaning of “throw,” the evidence is compelling that she is privileging physics words and ideas over everyday words and ideas when producing her answer. Only because Leona and Rachel frame the activity in such a way that colloquial meanings are seen as inadequate are they able to convince themselves the problem describes the horizontally projected versus dropped situation in the face of repeated use of the word throw to characterize the pitchers’ action on the ball.

Testing our Interpretation

If our framing-based explanation of why these participants misinterpret the problem is correct, a prediction follows: participants who arrive at their final answer by sense-making, specifically by including everyday/intuitive knowledge in their reasoning, should not misinterpret the question. This prediction emerged from and is consistent with our analyses of the sixteen participants recruited from introductory college physics classes. To test this prediction, we analyzed the responses from the eight non-science participants. Since they had taken fewer

previous science classes, they were presumably less likely to frame their activity as answer-making. One of these participants asked the interviewer for clarification and was told to look at the question; the other seven decided upon the correct interpretation quite quickly. As predicted, all eight participants both interpreted and answered the question correctly.

CONCLUSION

We have argued that participants who misinterpret the two-thrown-balls questions do so partly *because* they frame their activity as answer-making, in which they privilege formal classroom knowledge over everyday/ intuitive knowledge. If this pattern is borne out by further think-aloud data, we will have shown that misinterpretations of the problem serve as an indicator of epistemological framing. So, in this case, instead of threatening validity, misinterpretations signal the phenomenon we are studying.

REFERENCES

1. D. Hammer, A. Elby, R. E. Scherr, and E. F. Redish, “Resources, Framing, and Transfer,” in *Transfer of Learning from a Modern Multidisciplinary Perspective*, edited by J. Mestre. Greenwich, CT: Information Age Publishing, 2005, pp. 89-120.
2. E.F. Redish, “A Theoretical Framework for Physics Education Research: Modeling Student Thinking,” in *Proceedings of the Enrico Fermi Summer School, Course CLVI*, edited by E.F. Redish and M. Vicentini. Amsterdam: IOS Press, 2004.
3. P. Hutchison and R.M. Goertzen, presented at the summer meeting of the American Association of Physics Teachers, Greensboro, NC, 2007.
4. K. A. Ericsson and H.A. Simon, *Protocol Analysis: Verbal Reports as Data*, MIT Press, Cambridge, MA, 1993.
5. American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, *Standards for Educational and Psychological Testing*, American Educational Research Association, Washington, 1999.
6. G. Bateson, “A Theory of Play and Fantasy”, in *Steps to an Ecology of Mind*, edited by G. Bateson, Chandler Pub. Co.. San Francisco, 1972.
7. E. Goffman, *Frame Analysis: An Essay on the Organization of Experience*, Harper & Row, New York, 1974.
8. D. Hammer and A. Elby, “On the Form of a Personal Epistemology,” in *Personal Epistemology: The Psychology of Beliefs About Knowledge and Knowing*, edited by B. K. Hofer and P. R. Pintrich, Lawrence Erlbaum, Mahwah, NJ, 2002, pp. 169-190.
9. D. Tannen, *Framing in Discourse*, Oxford University Press, New York 1993.