A case of productive confirmation framing in an introductory lab

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Introduction

Most students in first-year courses expect the purpose of physics experiments in instructional labs to be confirming known results (Wilcox & Lewandowski, 2017). Prior research suggests that these expectations are problematic for learning, leading students to:

- Find lab to be "useless" and/or dismiss discrepant data as vague "human error" (Lippman, 2003)
- Disregard or manipulate data to produce the expected results (Smith, Stein, and Holmes, 2020).

We present a case-study of students whose confirmatory framing, we claim, engenders productive behavior in lab.

Methodology

This work is part of a larger project studying student behavior in labs designed to promote student agency in designing experimental methods and drawing their own conclusions.

The data comes from recordings of video calls between instructor and virtual students (due to the hybrid format of the lab), with students in groups of 2 or 3.

This case study was selected because it was surprising and puzzling: we did not expect productive behavior to co-occur with such clear expectations of confirmation.

Data

Task: Design & conduct an experiment to investigate and test the predictions of Galileo with respect to pendulum motion

- The instructors anticipated students would find evidence against one of Galileo's claims, that the period of a pendulum does not depend on amplitude.

Peter and Holly are in-person at the same lab table, while Judy is virtual. These names are pseudonyms.

Problematizing: "Is it not supposed to change?"

This conversation begins after they finish collecting data.

Peter: I mean so we are clearly seeing very slight changes. I think we had the same thing last time that the amplitude seemed to change it just a tiny bit. I wonder what about like how we’re doing it is making it change it consistently?

Holly: Is it not supposed to change?

Peter: It should be the same regardless of amplitude. But I guess there must be something else that we’re doing that’s making it change just a little bit, although it’s very insignificant.

Judy: But I feel like the correlation is too strong to ignore, like it makes sense, like it’s decreasing very slightly as you decrease the amplitude

Peter: Yeah, I mean I think looking at our data, it would seem that it is related, but just at a really small ratio I guess, so like the amplitude has a really small effect. But like, I know, theoretically we shouldn’t be seeing any effect. So, I wonder what about what we’re doing is making it look like that.

Sensemaking: "where is the error coming from?"

Next, Holly and Peter attempt to figure out how their apparatus could have produced their results.

Holly: I wonder if error could also be in the drop itself. Like if you don’t just like [noises] take your hand directly away, like if it’s like cushioning it at all. But like, I don’t know how that would...

Peter: Yeah, so I mean, that could be it. Do we think, can we think of a reason why it would be a larger effect at a higher drop. I mean, say it’s staying exactly where it is for a little bit before it start to fall

Holly: Well, I don’t know. Cause like if you only bring it out to here, it has more velocity in the x direction than the y direction whereas up here... If you bring it up like, here, it’s like this, this one is... well it’s not like we’re going past 45, but like there’s more velocity in the y direction up, up at a higher point... maybe?

Sensemaking: Revisiting the data

As they work to plot their data, Peter and Holly continue their attempts to explain the trend.

Holly: It’s interesting how much close the, 40\(^\circ\) and 30\(^\circ\) values are compared to the 10\(^\circ\) and 20\(^\circ\) ones. [...] So, I wonder if using a bigger amplitude would have us— or a larger amplitude would allow us to have more accurate results in accordance with the theory

Peter: It’s possible. Yeah, I think it would probably be easier to measure for larger amplitude because we are— it’s a more extreme end of the, or more extreme peak

Holly: So then maybe it is a timing error for the smaller ones.

Peter: It might be. [...] Okay, so that, yeah that’s our graphs with like really exact numbers. This, this still feels very within margin of error, given our...

Analysis

The discrepancy between their results and expectations leads to a rigorous examination of how their apparatus could have skewed their data. This hesitation to abandon their theoretical model is an example of scientific skepticism. Their problematizing and sensemaking not only co-occurs with confirmation framing, but we claim that their confirmation framing engenders productive behavior.

Why?

Epistemic Agency: Holly, Judy and Peter take their data seriously as a meaningful reflection of the phenomenon they have constructed — as something that needs to be explained and reconciled with their theoretical understanding.

Problematizing: The trend in their data seems to be a genuine problem for them. Peter says they “clearly” see consistent changes in their data, and Judy asserts that the correlation is too strong to ignore. They invoke a mathematical intuition that a neat correlation means the trend is not random. They do not ignore this problem, making repeated efforts to construct an explanation for the data.

Theoretical Constructs

Our research is organized by the construct of framing

- Framing describes how an individual or a group interprets what is taking place — To frame an event is to tacitly answer the question “what is it that’s going on here?” (Goffman, 1974)

- For example, Students may frame an activity as an opportunity to construct knowledge or as a chance to demonstrate the correct understanding.

We are interested in students “doing science”, which can look like the following:

- Sensemaking: “a dynamic process of building or revising an explanation in order to ‘figure something out’ — to ascertain the mechanism underlying a phenomenon in order to resolve a gap or inconsistency in one’s understanding” (Odden & Russ, 2019)

- Problematizing: the “work of identifying, articulating, and motivating the problem that needs solving” (Philips, Watkins, and Hammer, 2017).

Peter adds a trend line to their plot.

Holly: Unfortunately, it’s not super horizontal

Peter: Yeah, I mean it, I think actually it is close enough to horizontal because of how small our axes is. Like if I zoom this out, if I go from like 0 to 2. Like it’s extremely horizontal

Holly: Do we want to make another copy of this graph, show a zoom-in version versus a zoomed-out version?

Peter: We could do something like that.

Holly: And be like, despite what it looks like this line is actually fairly horizontal.

Whether this discussion is sensemaking or a questionable research practice is ambiguous: their conclusion that the trend is insignificant is plausibly appropriate, even if their explanation lacks physical or mechanistic reasoning.

References


