

“Let’s just pretend”: Students’ shifts in frames during a content-reinforcement lab

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With ongoing calls to engage students in science through physics lab instruction, understanding how students frame lab environments informs instructional approaches that promote students’ productive engagement. To deliberately identify students’ frames in a new lab environment, two students who were previously in experimentation physics labs were placed together during the first activity of a content-reinforcement lab. The students initially framed the activity as exploring the phenomena and developing investigations, similar to the previous semester. However, their frames rapidly shifted to filling out a worksheet as they watched their peers finishing the lab. These results demonstrate the speed at which students’ frames can dramatically shift as they enter a new lab environment. As goals for lab instruction transition, attending to students frames throughout their undergraduate lab experiences will be vital for promoting positive learning experiences.

I. INTRODUCTION

With calls to provide students with engagement in authentic science in the classroom [1–4], many curriculum developers are responding by transforming instructional laboratories (labs) to engage students in experimentation. However, students entering their introductory labs may expect to experimentally confirm results introduced in lecture portions of the course [5–8], which may limit the experimentation decisions they see available to them. Furthermore, these expectations lead some students to engage in questionable research practices [8–10]—behaviors that may call into question the objectivity of experimental results [11]—even when labs are designed to engage students in experimentation. Some evidence suggests that through instruction aimed at teaching experimentation, some students’ expectations about the purpose of labs shift to accommodate alternative understandings of the purpose of labs [10].

A person’s stable set of expectations about an activity taking place is their *frame* [12–14]. For lab activities, a student may expect they are to obtain data that agrees with a model [8, 10] and their behaviors and decisions coincide with this frame. Students’ frames may shift during an activity due to, for example, identifying an alternative instructional intent, how their peers are acting, or instructional moves [14]. Therefore, understanding and attending to students’ expectations and resulting frames as well as identifying mechanisms by which frames shift may improve lab curricula.

The aforementioned studies of students’ expectations in labs analyzed data from students who were entering an open-ended, non-confirmatory lab after prior lab experiences where they were expected (or perceived that they were expected) to confirm known results [8]. To our knowledge, there is no research on the opposite: Students enter a physics lab environment where they are highly constrained in their procedures and outcomes but their prior lab experiences are in physics labs designed to engage students in experimentation (i.e., labs such as those described in Refs. [15–22]). Sudden transitions in instructional environments provide a venue for identifying students’ shift in frames throughout a single lab period. In this paper, we aim to explore students’ frames as they transition from high-engagement in labs focused on the experimentation process to labs with prescribed procedures and outcomes.

To explore this transition, we specifically selected students who enthusiastically engaged in experimentation lab activities in the previous semester but were enrolled in content-reinforcement labs in the subsequent semester. We explore the group’s frames in their first lab activity of the second semester and aim to understand how prior lab experiences influence frames and inform students’ behaviors as well as identify mechanisms for shifts in frames. This serves as preliminary work to exemplify how changes in instructional intent of labs may affect how students approach and engage with the activities.

II. CONTEXT AND METHODS

We analyzed video data of students who were enrolled in the second course of a three-semester introductory sequence intended for physics majors and minors. At the time, the lab components of the course sequence were undergoing curricular changes from content-reinforcement labs to experimentation labs. As part of the development for this cohort, half of the lab sections were testing experimentation labs and the other half were using content-reinforcement labs. Therefore, at the beginning of Semester 2 of the course sequence (electricity and magnetism), there were students with different prior experiences in each type of lab. This curricular structure allowed us to collect data to understand how students reacted to different instructional labs with knowledge of their prior lab experiences.

In the *experimentation* labs, students were provided with structure around the experimentation process and expected to make more experimentation decisions as the semester progressed. However, the direction of the investigations were driven by students’ results and ideas. In the *content-reinforcement* labs, the lab instructions laid out all of the experimentation decisions with the intent that students focus on conceptual reasoning. The lab instructions provided students with specific guidance about how to perform investigations. Individually, students wrote answers to conceptual questions prompted in the lab instructions and were graded on completion. An analysis of the instructions for content-reinforcement and experimentation labs can be found in Ref. [23], and demographic information for cohorts in this course sequence is provided in Ref. [20].

The focus of this paper is the first content-reinforcement lab of Semester 2. This lab activity consisted of a series of electrostatics investigations for which students were expected to conceptually explain the charge movement. The investigations included moving charged rods around an electroscope, a pompom, empty aluminum cans, styrofoam peanuts, and paper balanced on a paper clip. Other electrostatics phenomena were explored through a pie plate and styrofoam (acting as an electrophorus) and a pith ball.

A. Participants

In this study, two students (Anders and Jesper) were in the experimentation labs in Semester 1 (mechanics) and then in the content-reinforcement labs during Semester 2. We intentionally placed them in a group during their first lab activity at the beginning of Semester 2 to observe how they reacted to the new instructional environment. In Semester 1, both students appeared highly bought-in, excited about the lab activities, and regularly assumed leadership roles. The students were in different lab sections during Semester 1, and based on their initial conversations, they had not interacted prior to this lab.

Jesper was a positive contributor to his prior groups and consistently put in thought and effort. At the begin-

ning of the lab activity, Jesper described his engagement to Anders as “*I was good at thinking up questions but was very compulsive and not that patient,*” which also agreed with our observations. Anders did not tell Jesper information about his engagement in prior lab activities, but from observations, he often led his group in systematic investigations and kept reasonable expectations while carefully weighing several avenues for investigation. Both students were enthusiastic and collaborative, and the instructional team from Semester 1 recommended both students to be undergraduate teaching assistants. E. M. S. interacted with Jesper in focus groups and occasional instructional contexts.

As researchers, we want to state that: (1) the video cameras were visible to students and (2) all students in the room were aware that multiple video cameras were recording the lab session and that some video cameras were focused on groups of students who consented to participate in video research. During the week prior to this lab activity, Anders and Jesper chose to continue to participate in video research when we provided a refresher about how to provide and revoke consent. Anders and Jesper regularly demonstrated enthusiastic participation in video research during Semester 1 with actions such as asides to cameras in the style of “The Office” and choosing to sit at the tables that were recorded. During the lab activity in this paper, Anders and Jesper occasionally used the microphone to directly inform E. M. S. (using first names) about what was happening and performed “music” for E. M. S. with the lab equipment.

B. Video analysis

E. M. S. watched the video in full and without taking notes to understand the dynamics that played out over the lab session. During the second watching, E. M. S. took notes of the students’ interactions and expectations. Then, during a third viewing, E. M. S. wrote a descriptive narrative of the students’ behaviors and interactions and transcribed many of the students’ conversations. In the narrative, we paid particular attention to the students’ engagement where they were not strictly following the lab instructions and described why they made those decisions, suggesting their frames. From this narrative, we selected episodes to exemplify the ways that the students framed the lab. The episodes are presented chronologically to provide an overview of how the students’ frames shifted throughout the lab session.

Because this is a preliminary study, we were not aiming to generalize beyond the two students but identified some features that may be useful for researchers who are investigating students’ frames, especially as they transition between different modes of lab instruction.

III. RESULTS

We claim there are two broad frames represented in this analysis: (1) exploration and investigation of physi-

cal phenomena in Episodes 1 and 2 and (2) filling out worksheets in Episodes 3 and 4. We selected these episodes for this paper because they present distinct manifestations of these broad frames.

A. Episode 1: Play time before the lab begins

Jesper and Anders arrived to their lab about ten minutes prior to the official start time. During this time, they never referred to their lab instructions but explored many of the demonstrations at their lab table. While they were joking around and playing, they also demonstrated natural scientific curiosity and jokingly related their play to scientific investigations. Prior to the start of the lab period, the students were engaging in behaviors that we regularly observed during the previous semester, suggesting that they framed the activity as exploring physical phenomena.

Jesper pulled his computer charger out of his backpack with a goal of charging the rods faster than with the wool cloth. After a short conversation about possible risks of electrocution with Anders and other nearby students, Jesper returned to charging the rods with the wool cloth. For Jesper, this behavior was similar to the behaviors he engaged in during the previous semester and reflects his self-description of impulsivity and developing questions to investigate.

Shortly after, again without looking at lab instructions, Anders and Jesper started playing with the rods and a bowl of foam peanuts. Jesper quickly realized that the peanuts were only attracted to the middle of the rod he was charging, and Anders asked “*is that where you were rubbing it?*” and suggested they develop an experiment to test his idea. Jesper devised a test by rubbing the wool cloth on the tip of the rod and then brought it near the peanuts and expressed “*bro, the experiment is coming up false*” when the peanuts were not initially attracted to the rod when the rod was positioned with the hollow part facing the peanuts. After slightly changing the position of the rod, Jesper changed his conclusion “*oh wait! No, no, experiment successful!*” Anders then encouraged testing the middle of the rod again for “*reproducibility*” to which Jesper agreed and expressed “*yo, that’s like one of the qualities of a good experiment.*” While this test was partially joking around, through their jokes they actively carried out and discussed properties of scientific investigations.

B. Episode 2: Curiosity sparks investigation

Once the lab session officially began, Anders and Jesper pulled out their lab instructions and began to read and follow the lab instructions, typical of students in video of other content-reinforcement labs. However, in the early investigations, Anders and Jesper frequently were distracted by observations of the phenomena and deviated from the step-by-step instructions. Episode 2, and others, suggest that Anders and Jesper framed the

lab as an investigation that was loosely guided by the instructions, similar to experimentation labs in the previous semester.

Initially, they closely read the instructions and asked each other questions such as “*when can we touch [the electroscope] with the PVC pipe?*” and looked through the instructions for answers, which ended abruptly with an exchange between Jesper (J) and Anders (A):

J: “*How do we know [the electroscope] is negatively charged?*”

A: “*It’s only going to be like negative movement.*” (presumably movement of electrons)

J: “*Can electrons go outside of the PVC pipe?*”

A: “*We know [the PVC pipe] is negatively charged.*”

J: “*But how do we know that [the PVC pipe] is negatively charged?*”

A: “*Oh, [the lab instructions] told us.*”

J: “*But is there a way to like experimentally? I mean, probably not.*”

A: “*I think the way the static thing works is like giving, [the wool cloth] donates electrons really easily... I think you’re just giving it extra electrons as you’re rubbing it.*”

Within this conversation, Jesper suggested an experimental approach to determining the sign of the charges. Early on, Jesper consistently suggested small experiments to test different ideas and often Anders agreed. However, Anders began to rely on the lab instructions for information pertaining to the investigations.

The students continued to discuss charge movement, which led them to wonder whether charges were transferring from the rod to the electroscope. Jesper suggested “*we could actually try that, bring it close and see if we get [the effect].*” They found that the effect happened when the rod was close but only maintained when the rod touched the electroscope, which led the students to conclude that there was a transfer of charge. When checking back to what they were supposed to be doing according to the lab instructions, Anders found “*oh wait, I think that’s the next thing!*” to which Jesper replied “*yo, we’re ahead of the game!*”

During the early portion of the lab period, Anders and Jesper had several discussions similar to this episode where their curiosity about a physical phenomenon distracted them from following instructions. This behavior occasionally required them to repeat portions of the activities and slowed progress compared to their peers. However, in the experimentation labs the previous semester, students were expected to follow-up on interesting observations. Anders and Jesper appear, at first, to frame the lab activity similarly to experimentation labs: Students are expected to explore phenomena and test different explanations for observations.

Shortly after, Jesper asked Anders “*do our answers even count?*”—speaking generally about the purpose of filling in the questions—and Anders replied “*I don’t even know how any of this works,*” which suggests the students may have recognized a conflict of their frames with the

lab instructions. Episodes 3 and 4 suggest the students transitioned away from their initial frame and began to understand the activities as filling out a worksheet.

C. Episode 3: Following directions with guidance

About halfway through the lab, with an activity using the packing peanuts, Anders and Jesper’s behaviors began to signal a shift in their frames. Rather than working within their group, they interacted with a group who had completed the series of questions and provided them with answers. Episode 3 marked the first time that Anders and Jesper quickly reached out to others to obtain answers to the prompts. At the same time, they continued to attempt to understand the physical phenomenon, which suggests a transition point in their frames during the lab session.

They began by reading the instructions out-loud then began a discussion about polarization in insulators, to which a nearby group (G) contributed:

A: “*So my guess is the styrofoam gets polarized. How does it get polarized if it’s an insulator?*”

J: “*I guess it’s a conductor! Physics is wrong!*” [then seriously] “*it’s gotta be a conductor though, right?*”

A: [Makes sound indicating disbelief]

J: “*How would, I don’t really know what’s a conductor or insulator on my own.*”

A: “*I feel like it’s definitely not a conductor.*”

J: “*But wouldn’t it still have charge zero so then the force would be zero?*”

G: “*I think it gets polarized.*”

J: “*Yeah, but how does it get polarized?*”

The nearby group provided an example of a series of paperclips picked up by a magnet, explaining that paperclips are not magnetized on their own. The explanation did not stick with Anders; he asked Jesper “*but how are we polarizing it?*” A member of the nearby group immediately chimed in with a new explanation using his hands to represent charge separations in conductors by moving his hands far apart and then in insulators by moving his hands slightly apart. Jesper exclaimed “*oh, it’s like individual, it’s like every atom!*” and Anders indicated his agreement with the explanation.

Episode 3 demonstrates that Anders and Jesper continued to prioritize conceptual understanding of the phenomena, as indicated by their questioning of how the polarization occurred. However, simultaneously, they started to fast-track the process by involving a group who had completed the question. These interactions suggest a transitional period where the students began to frame the lab activity as filling out a series of questions on a worksheet while maintaining attention to understanding the physical phenomena. Episode 3 is distinct from Episodes 1 and 2 because the students did not develop their own investigations in response to their observations.

D. Episode 4: Pretending to observe outcomes

Toward the end of the lab, Anders and Jesper had two remaining investigations while many of their classmates packed up and left. This, seemingly, caused them to abandon scientific investigation altogether, and, instead, they answered the questions posed by the lab instructions without carrying out the investigations. These behaviors signal a full shift of the students' frames to filling out worksheets, abandoning exploration and testing physical phenomena. Episode 4 occurred when the lab instructions called for using the electrophorus to briefly light up a fluorescent bulb.

At the start of the investigation, a nearby group stated *"it doesn't light up but it's supposed to light up"* and Anders glanced over and repeated the group's finding to Jesper. Jesper reacted by trying to charge the electrophorus even more, however, Anders said *"we can do the rest of the questions without actually... let's just pretend that it happens."* Jesper, who was aware of the nearby recording microphone but apparently unaware it was directly linked to a camera, spoke into the microphone *"they're recording us, bro, we gotta go all the way."* Anders then asked *"is there a camera?"* to which Jesper replied *"I think they're just recording what they can hear."*

To demonstrate their engagement in the investigation to the researchers, the students started making overblown claims about the fluorescent bulb. Jesper exclaimed *"oh my god, it's glowing! Holy cow!"*, despite the fact that the fluorescent bulb would only briefly flash given the set-up of the apparatus. Anders fed into the fake excitement with *"oh wow!"* Jesper continued with *"yo, it glows! Wow, that was cool!"* and Anders with *"crazy!"*

The students returned to conceptually reasoning about what they were supposed to observe, however, they did not observe the phenomenon at any point. After their conceptual discussion, Anders flipped to see more pages to the lab instructions and asked *"did we skip this?... Oh, let's just pretend. And by pretend, I mean do it."* Jesper immediately clarified to the microphone, *"yes, we're doing it!"* The students proceeded to conceptually discuss the questions outlined in the lab instructions but did not fully carry out the outlined investigations.

At this point in the lab session, Anders and Jesper's engagement drastically changed. They switched to conceptual discussions about the expected outcomes and believed they were expected to make the observations in the lab instructions. As evidenced by pretending to observe the phenomenon, alternative experimental outcomes were not acceptable. Furthermore, their motivation to engage in conceptual discussions may have been due to the audio recording. The video data suggests that the students' observation of their peers leaving the lab motivated a frame shift to filling out a worksheet because it was faster than fully completing the investigations. As suggested by our video recordings of other students in content-reinforcement labs, their peers were probably going through the lab questions without engaging in im-

promptu experiments and conceptual conversations.

IV. DISCUSSION

As lab instruction transitions to emphasize different instructional goals, students' frames will affect how they perceive and engage in the activities. Therefore, understanding how students frame lab activities will inform curriculum developers and instructors to anticipate and attend to students' engagement from their exhibited frames. In this paper, we identify two broad frames with which students approached the lab activity: (1) investigation of physical phenomena and (2) filling out worksheets. The students' shift from one frame to the other may have been due to their observations of peers' behaviors and pacing of the activity, but the students' initial frame is similar to how they engaged in Semester 1 experimentation labs.

Anders and Jesper began the lab as inquisitive students, as evidenced by their playful approach to investigation prior to and at the beginning of the lab period. This initial frame suggests that the students framed the activity in a similar way to their Semester 1 experiences in experimentation labs. As they progressed through the activity, they became motivated to complete the activity by filling out the questions. Because the students were aware of the recording, they chose to pretend to complete investigations for the recording rather than engage in the activity as they assumed they were expected. The presence of the recording changed the students' conversations, however, their actions—choosing to skip the execution of several tasks despite the recording—appeared to align with what they would do, regardless. The significant shift signals that the students came to frame the activity as filling out the worksheets, which was likely influenced by observations of their peers finishing before them and may be similar to Ivy and Charlie's desire to be done described in Ref. [8].

As curriculum developers and instructors, we should be aware of how students' frames shift when instructional goals of labs are changed. Here, Anders and Jesper initially used their approaches from the previous semester's lab activities, however, they rapidly shifted to a frame that prioritized completion speed over scientific investigation. Increasing opportunities to frame labs as authentic physics investigations can assist in developing students' identities as physicists [24], suggesting the importance of supporting and developing students' curiosity about and investigation of physical phenomena. Creating opportunities for students to engage in the process of science may be most beneficial when spread across the curriculum so that students may build on their skills in a productive frame.

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