Destabilizing a Target Idea Framing to Expand Epistemic Agency

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Abstract: In this paper we present a case study of knowledge building (Scardamalia, 2002) in a college biology lab course. We use *epistemic agency* (Miller et. al. 2018) and *framing* (Tannen & Wallat, 1987) to explicate an expansion in the types of opportunities for knowledge building our focal student, Caleigh, perceived herself as having as she entered the final unit of the course. This analysis shows how attending to framing can be leveraged to promote disciplinarily productive practice and epistemic agency in designing for students doing science.

Introduction

There is a long-standing push in science education reform to "engage students in knowledge construction—to position them as *doers of science*, rather than *receivers of facts*" (Miller et. al. 2018, p. 1056). Designing for doing science involves positioning students with opportunities to shape knowledge building—that is to exercise *epistemic agency*—and fostering engagement with disciplinary ideas and practices, two goals which are frequently in tension (Hammer, 1997). The heart of this tension is not knowing *what* knowledge building opportunities students will take up (and a worry that those they do take up will not have disciplinary merit). This raises the need to examine *why* students take up the opportunities they do, and how that is influenced by curricula.

In design this tension manifests as a tradeoff between providing support that can help students engage with disciplinary practices and ideas, and designing in uncertainties with the hopes that students will themselves identify those uncertainties as a motivation to engage in practices. Thus the design challenge is posed as a balance between resources and opportunities to encounter problems, as in work leveraging material resistances (Manz, 2015) and generative resources (Ford, 2005). These approaches are structured to provide compelling *whats* for students to take up, but their success (and that of any curriculum) relies on students *seeing* opportunities and acting on them.

Miller, Manz, Russ, Stroupe, & Berland define epistemic agency as "students being positioned with, perceiving, and acting on opportunities to shape knowledge building" (Miller et. al. 2018, p. 1058). Attending to student *perception* provides a useful lens for understanding what opportunities students might take up in more open learning environments. The construct of *framing* (Tannen, 1979) has been used in education research to better understand how students interpret what is going on in learning spaces (Scherr & Hammer, 2009). Framing can provide a *why* for understanding *what* opportunities students notice when positioned to shape knowledge building.

Building off this prior work we present a case study of a student, Caleigh (ps), who experienced a disciplinarily productive expansion in the types of knowledge building opportunities she perceived herself as having between the second and third units of our intro biology lab course. We argue that this expansion involved *destabilizing* her framing lab as a place where she's expected to demonstrate knowledge of a single, target idea. In presenting this argument we highlight design features of the course which facilitated this destabilization. This analysis connects student framing of learning spaces to their perception of epistemic agency in those spaces, which has implications for designing for students doing science.

Study context—Design for doing science

The study context is a large introductory college biology lab course taught by graduate student teaching assistants. The course is designed to promote students doing science, in the sense noted above—balancing student-centered inquiry with engagement in the disciplinary content, in this case evolution and ecology. To provide space for inquiry the course is split into units, each spanning three weeks. Each unit is centered on a model study system (Table 1), chosen in part for their open-ended behavior which provides many opportunities for encountering disciplinary productive uncertainty (Manz, 2015). As an example, in the *E. coli* study system students compare the fitness of two strains of bacteria with differing mutation rates grown in various environments. The system exhibits dynamics of varying advantage for each strain across time scales and growth media, which can lead to generative ideation about how scientists measure and understand fitness.

We designed four interconnected activity structures to provide opportunities for encountering and engaging with uncertainty, and communicating scientific reasoning: Discussion, Experiment, Simulation, and Lab Report. The enactment of these activity structures shifted between lab units. In L1 there was greater emphasis on student interpretation of results, enacted by engaging with the computer simulation after collecting experimental

data, and by extended discussion. In L2 students began to provide input into the experimental procedure by selecting the conditions under which to grow the C3/C4 plants. In L3 students generated their own research questions and designed experiments to address those questions (see Table 1 for a summary of activity structure changes).

Table 1: Study systems and activity structure for each unit of the lab course

Unit	Weeks	Study System	Activity Structure
L1	1-3	E. coli Bacteria	Open discussion; Closed experimental procedure
L2	4-6	C3 / C4 plants	Students decide experiment conditions but not measures
L3	7-9	Bean Beetles	Students decide research question & experimental design

Methods

Data for this study come from hour-long, semi-structured interviews, conducted at the start, middle, and end of the semester (1). To better understand how students were experiencing the reformed lab structure (see above) we asked them to recall moments in lab associated with a valence, such as "moments that were challenging" or "moments that were exciting." The constructs central to this analysis – epistemic agency & framing – emerged from attempting to account for differences in the nature of Caleigh's reported inquiry between the second and third interviews.

Following Miller et. al.'s definition of epistemic agency we turn our attention to what opportunities for knowledge building Caleigh reports *perceiving* herself as having and *acting on*. This provides insight into the nature of Caleigh's inquiry; what does she see herself as investigating, as indicated by what she sees as an available and appropriate course of action in moments of decision-making. In this interview context, evidence for knowledge building opportunities include depictions locating uncertainty about what to do, as in "it gets kind of confusing because I am not sure exactly how to proceed with my lab report;" and descriptions of what she actually did, or habitually would do, or felt she could not do in uncertain moments, as in "if we got, results that showed our C3 plants did better, um like, we can't really write a lab report saying C3 plants do better."

Framing helps us to understand *why* Caleigh perceived only certain opportunities for knowledge building in Labs 1&2 and others in Lab 3. Framing is a construct of interpretation and interaction (Tannen & Wallat, 1987). Students who frame a discussion as a space for argumentation might notice inconsistencies in a claim and raise those to peers, while those who frame a discussion as a space for idea-sharing might seek correct answers and offer those to the instructor (Berland & Hammer, 2012). Framing is dynamic (ibid) and spans multiple time scales (Scherr & Hammer, p. 172). Given the one-interview-per-unit context, framing in this case refers to Caleigh's sense of the point of each lab unit. It is evidenced by her justifications for her interactions, as in "I analyzed data that would have been more, correct and (laughs) like I don't want to say/ that data is correct just like um, what the lab instructor expected us to see," and from statements where she interprets what she should do in lab, as in "I am pretty sure that we were given the question we were supposed to answer… we weren't expected to like incorporate all the other stuff."

Findings

In this section we show that Caleigh's sense of what opportunities she had for knowledge building expanded between the second and third lab, and that this was connected to a destabilization of her framing the lab course as about demonstrating a target idea for each unit. We will start by presenting representative examples of knowledge building opportunities Caleigh perceived herself as having and acted on in lab unit two (L2) and unit three (L3). Next we will illustrate what we mean by her target idea framing in the first two labs, and show how she took up one curricular tool—the simulation—in a way consistent with this framing. Finally we'll show that the target idea framing was destabilized in the third lab unit, and see how this helped to expand the knowledge building opportunities Caleigh saw herself as having.

In characterizing Caleigh's perception of knowledge building opportunities in L1 & L2 it's important to note that she sees herself as having more agency than in prior lab courses, stating that what surprises her the most is that "the whole *process* (is) more open-ended." (I2, 5:41) When uncertainty around interpreting data arises in the first two labs, however, Caleigh's consistent action "is just to like- to take into account everything that could have gone wrong and just like lay it all out there." (I2, 41:45) Caleigh sees her agency as limited to "look(ing) for places we made mistakes" when "our results (don't) match what we expect to happen." (I2, 35:54) At no point during any interviews does Caleigh indicate that she could interpret the data from L1 & L2 differently from this expectation. Any deviation is characterized as a *mistake* in carrying out a protocol, a point on which she is very specific during her third interview, noting "everyone's given that same piece of paper, so our results should more

or less be the same as those of our classmates. So it was really obvious if one group did something wrong." (I3, 17:20)

By contrast, Caleigh sees herself as having additional opportunities for knowledge building in the third lab unit, as she continues from the quote above "but with lab three… it was more of like- figuring out, what each group found from the results, like from th- *doing* the experiment, and not like whether or not each group did it correctly." (ibid) She reports *wondering* (about the biological system behavior), and "trying to figure out what *factor*, was making certain beans more appealing." (I3, 1:16) Her activity is expanded beyond looking for mistakes in carrying out a protocol to "wr(iting) like two, mini lab reports within one like, analyzing the two different (results)" her group and her peer group got (I3, 10:52). This represents a marked expansion of Caleigh's sense of what sort of knowledge building she can do when she encounters uncertain data. For us the question is, what contributed to her expanded sense in L3? She hints at curricular elements that cued to her a certain approach to learning in L1 & L2, as she noted above with everyone having "that same piece of paper" (i.e. the same experimental protocol). Next we try to better understand the nature of such a cue by explicating her framing lab units 1 & 2 as about demonstrating a target idea.

During the second interview, Caleigh mentions "I think like the point of the lab (Unit 1) was just to see like which strain would do better in which environment." (I2, 31:20) Later, when describing writing up the lab report for L2, she notes "one thing we are looking for is like whether or not our results match what we expect to happen." (I2, 35:54) For both L1 & L2 Caleigh is able to articulate a very specific *target idea* which forms the basis for the results she expects to get from carrying out the experiment. In both cases this idea is ascribed to some external authority: "from like a bio,lo,gist's point of view our lab instructor told us like we were supposed to see…" (I2, 24:37) or "every bio textbook out there will tell you." (I3, 21:10)

When we say that Caleigh *frames* the lab as about demonstrating these target ideas we mean that she interprets curricular tools, and her activity in response to them, according to this framing. The most exceptional example of this is Caleigh's uptake of the simulation in the first two labs. Caleigh uses the simulation in a way we as designers did not intend, stating "at least my group we, we trusted, that we did the experiment right if that reflected what we saw in the computer simulation... Just because I feel like when we are doing something there's a lot more room for error than if a computer is doing something." (I2, 58:24) This interpretation of the role of the simulation is consistent with the target idea framing—that in lab the thing we're doing is illustrating a concept by generating pre-determined results—and her associated attunement to *error* in carrying out a protocol.

While framing helps to explain how Caleigh interprets curricular tools, and thus impacts her perception of opportunities for knowledge building, it is also sensitive to curricular structure. The curriculum in the third lab is set up in a way that *destabilizes* Caleigh's target idea framing. One clear feature that contributes to this is that students designed their own experimental protocols. As noted above, Caleigh saw the instructor-provided protocol, in L1 & L2 as "that same piece of paper" that cued her to expect all students arrive at the same, particular answer. By contrast, when students design their own experiments "it would be impossible (for the instructor) to have, a checklist for like what each group needs to include." (I3, 45:59) The "impossibility" of a single experimental outcome accounts for instructor expectation of what students can and should do in lab, including demonstrating a target idea. This framing is further destabilized by a shift in epistemic authority for interpreting experimental results. Recall that Caleigh previously invoked "a biologist's point of view" and "every bio textbook" when presenting the target ideas for L1 & L2, which set the basis for expected results from those experiments. In L3 her class conducted experiments in group "pairs," tacitly putting comparison of her experimental data against those of her peers, who she notes "in theory don't know much more than we do," (I3, 30:57) which destabilizes the right-or-wrong interpretative framework of the target idea framing.

Destabilizing a target idea framing means Caleigh does not see herself as constrained to identifying erroneous data (which does not confirm the target idea for the unit) in L3, because that's no longer the *point*. Removing this constraint opens the space of opportunities for knowledge building she perceives herself as having in uncertain moments, to include things like *figuring out* why the biological system behaves the way it does.

Discussion

In this paper we presented a case study of one student's expansion of epistemic agency between two units of a lab science course—that is, an increase in *what* opportunities for knowledge building she perceived herself as having, and acted on. This is significant for us as science educators because we see Caleigh's efforts at figuring out the dynamics of the biological system as engaging and building disciplinarily productive epistemological resources (Elby & Hammer, 2010) that sole attention to mistakes in carrying out an experimental protocol does not.

We made the case that attending to student *framing* of learning spaces is important to navigating the tension between productive disciplinary practice and epistemic agency in designing for doing science. In our case we enacted our curriculum in order to start with greater emphasis on the former at the expense of the latter. For

Caleigh this signaled a familiar school expectation—a target idea framing—which influenced how she perceived and acted on the curriculum. As a result her disciplinary engagement *and* epistemic agency both were constrained in the first two units of the course, and only expanded beyond those constraints when that framing was destabilized.

This implicates design considerations around the multiple, potentially conflicting, signals curricula send. Activity structures that *can* expand ideation when engaging with an open study system might not have their intended impact if students view the system, situated in a learning context, as closed. This is not to suggest a one-to-one correspondence between curricular structure and student framing. We've presented on the productive scientific engagement of one student in L2 of the same year (Hayes & Gouvea, 2017), who clearly saw that unit as open. It is our contention that framing provides an important lens for *dynamically* enacting curriculum to support students' doing science (Hammer, 1997).

Further work needs to be done connecting real-time framing of activity in learning spaces (Scherr & Hammer, 2009) to the longer time-scale framing presented in this analysis (and beyond to time-scales which transcend a single course). While framing at many time-scales appears sensitive to instructional context it is less clear how new, long-term framings emerge and become stable. Understanding this process would have implications for the longitudinal enactment of learning environments as knowledge building spaces.

Endnotes

(1) Full transcripts for the Second and Third interviews are available online. The first, pre-interview, is not used for this study.

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