Small Teacher Moves with Big Impacts in Shaping Students' Sensemaking and Intellectual Authority in Science

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Abstract

This study explores the epistemological framing dynamics in one middle school biology classroom and how those dynamics shape students' collaborative sensemaking in science. We trace how the teacher's instructional moves shaped students' framing, and the ways in which that framing influenced students' learning. Our analysis shows that while the teacher framed small group argumentation activities as spaces for students to generate and negotiate ideas, brief but influential moves at the end of the lesson, which emphasized the correct answer, undermined students' sensemaking and intellectual authority. These findings have implications for the design of teacher education highlighting the need to promote teachers' awareness of the impact of their instructional moves in terms of how students frame their efforts in the classroom.

Problem

Current efforts to reform science education envision science classrooms as sensemaking spaces where students engage in explaining natural phenomena, allowing them to develop a deeper understanding of the concepts of science as they hone their facility in the practices of science (NGSS Lead States, 2013). In this vision, students grapple with and socially negotiate their ideas about scientific phenomena – a vision that pushes against prevalent traditional classroom instruction (Banilower et al., 2018; Capps & Crawford, 2013) and requires a fundamental shift in that instruction (Peltzman & Rodriquez, 2013; Reiser, 2013). Specially developed curricula centered on practices core to science, such as argumentation and modeling (Marco-Bujosa et al. 2017; Sampson et al. 2011), and professional development (PD) programs that support teachers to engage in reform visions of instruction have the potential to influence this shift (McNeill et al.,, 2016; Moon et al. 2012). However, how a teacher takes up such curricula in their classrooms and how they implement reform-based instructional strategies may be influenced by their own pedagogical views of what science instruction should look like (National Academy of Engineering and National Research Council, 2014), which in turn shapes the vision of science that students come to understand. **To better understand these dynamics, the research presented here explores one middle school science teacher's effort to engage in reform-based instruction and how those efforts were shaped by his pedagogical views. In particular, we examine the epistemological framing dynamics (Wendell, Swensen, & Dalvi, 2019) in one lesson, tracing how the teacher's moves influenced the students' framing of their work, and the ways in which that framing influenced student learning.**

Theoretical Framework

Redish (2004) describes epistemological framing as encapsulating how learners understand their activities in terms of knowledge, reasoning, and learning. It is what they think about when considering "what is going on" in an activity. Science education researchers have employed this construct to understand how students interpret classroom cues to make decisions about their classroom efforts (Berland & Hammer, 2012; Hutchison & Hammer, 2010; Scherr & Hammer, 2009). More recently, researchers have turned this lens to understanding the work of teachers (Wendell et al., 2019). Taken together, the research suggests that it is important to recognize how contextual factors influence the way in which the participants frame an activity and thus make decisions about their efforts within that activity.

Design

Data for this study are drawn from Year 1 of a four-year project in which science teachers engaged in a year-long PD designed to foster teachers' abilities to support student sensemaking about science through talk. Here we focus on one middle school biology teacher, Jerry (all names are pseudonyms), and his instructional practice. We selected Jerry as our focal participant because we observed that while he provided space for students to collaboratively make sense as they engaged in argumentation, his lesson wrap-ups centered on providing the canonical content

knowledge. We wondered about the influence of these wrap-ups on students' framing of their work and their understanding of how scientific knowledge is generated and evaluated.

Data sources included classroom videos, teacher and student work products, and a series of open-ended and structured stimulated recall interviews with the teacher and students. Classroom video from three multi-day lessons were analyzed to broadly characterize and describe the different types of activities that comprised each lesson, informed by the analytical approach employed by Berland et al. (2016) and Wendel et al. (2019) (Table 2). We then used these characterizations to identify salient instructional moves within small group argumentation activities and culminating discussions that had the potential to frame student work towards or away from disciplinary science epistemologies. Teacher and student interview transcripts were analyzed using a constructivist grounded theory approach (Charmaz, 2006) to identify patterns and themes related to Jerry's perceptions of his own teaching, his views about science teaching and learning, and his students' understanding of the nature of science learning.

Findings

Jerry framed small group activities as collaborative scientific sensemaking spaces for students to examine and reason about data as evidence to support claims (Table 1). He framed these activities as science since he viewed them as opportunities for students to interact around scientific ideas, to collaboratively sense make, and to negotiate shared understanding of data as evidence to support a claim. Students spent an average of 43% of the total instructional time per lesson on such activities.

Jerry's instructional choices in wrap-ups, however, reduced the value of this sensemaking. Instead of orchestrating students' ideas to develop a consensus, Jerry consistently unveiled the "correct" answer (Table 2). While these "unveiling" activities took up a shorter amount of time (an average of 4% per lesson) than the group activities, the teacher's framing undercut the intellectual authority afforded to students when they collectively negotiated and made sense of scientific ideas during small group activities. For instance, when Jerry provided the correct answer, "the amount of predators" caused trends in the coloration of guppies, he shut down student understanding of how evidence is open to interpretation and can support different and competing claims. Further, his continued enactment of such sequences across the year set a norm in which students understood their work to be part of an elaborate routine of playing school.

Student interviews reveal that students understood that group activities were sensemaking spaces where they could explore data and collaboratively negotiate ideas. Many saw value in these negotiations because it made visible different ways of thinking and informed their own understanding; they also felt frustrated by remaining uncertainties, but they expressed relief that they ultimately received the "correct" answer to mediate some of these frustrations.

For example, one student described that the class would be "given a question" and then they would "try to find an answer and work in groups" to "understand, like, what other points of view" and "look at different ways you could approach and interpret the information." He described these negotiations as helping him "to see the different ways someone looks at the information." He saw this work as doing science "because we were trying to, like, explain why

something happens in nature" but he also found it stressful because "we couldn't agree so we weren't making as much progress as we would've liked." When asked if he had a sense of closure, he said "Yeah, because he did, uh, Mr. Jerry at the end, he did tell us what, like, the main reason..." When asked if the "correct" answer was always provided, the student explained "he'll usually shows the question first and then we'll discuss... he'll show what the correct answer is and then we have to do a write-up for that." This description aligns with what we observed in the classroom where students were provided space to sense make and to negotiate explanations. The expectation that the correct answer would be provided and that this answer was to be included in the final product framed the purpose of science to be the uncovering of correct answers instead of a process of knowledge generation towards a stronger explanation.

Jerry's interviews echoed students framing. Jerry identified that group activities and class discussions served different purposes. According to Jerry, group activities are spaces for "free thinking," sharing ideas even if incorrect, and working together to make sense of ideas. He described these activities as providing space for uncertainty and wrestling with ideas, but that data should be constrained so that clear and accessible conclusions are unobtainable. He perceived that his students saw his role to be the leader and the giver of "correct" conclusions. Interestingly, he described his personal preference for learning in similar ways to his own enacted practice. For instance, he noted that he enjoyed collaborative opportunities to wrestle with problems but indicated that he wanted a "more knowledgeable other" to provide the correct answer to an idea or problem.

Contribution

Years of effort have been devoted to the development and dissemination of research-based teaching approaches and curricula useful in those approaches, with all evidence suggesting that the success of these efforts is only having a marginal impact (Darcy & Henderson, 2008). When it comes to the vision of science teaching and learning presented in current reforms, the examination of the teacher presented here speaks to the ways in which relatively small teacher moves shape how students' frame their efforts in and understandings of science. These findings will be of interest to NARST members designing and offering PD as well as teacher educators more broadly, as our results suggest that it is not enough for PD to focus on understanding curricula and teachers' enactment of curricula. If students are to develop an understanding about what science is and how scientific knowledge is constructed and evaluated, PD experiences must help teachers to see the impact of their instructional moves in terms of the ways students frame their efforts in the classroom.

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Table 1. *Epistemological Framing of Small Group Argumentation Activities*

Lesson 1 - Framing	Instructional moves that supported this framing
Students as data collectors, sensemakers, and collaborators	Jerry introduced the argumentation portion of the lesson by clarify the different plant and animal cellular structures that students should observe as they examined different microscope slides of these organisms. He described that he would provide students with a known cell (i.e., plant or animal) and then they would get an unknown slide. Students would "**have to be able to try to identify characteristics**" to support their claim about what type of organism they thought was represented on the slide. Jerry asked students to create detailed observations notes and sketches of the cells structures to **serve as their evidence when they developed their arguments**. Further, he told the students they would need to work "**together to talk about and discuss what you think you see**." This introduction occurred during the first 3 minutes of the activity. For the remainder of the time (102 minutes across 3 days) students worked together with their group members to examine the cellular structures under the microscope and to negotiate their reasoning about whether the unknown organism was a plant or animal.
Lesson 2 - Framing	Instructional moves that supported this framing
Students as data collectors and sensemakers	Jerry introduced the argumentation portion of the lesson as an activity in which students were going **"to be assisting doctors" to try and figure out which of four patients had cancer based on the data they collected** from tissue slides. He told students they were "looking for some of the differences described" in the lab diagram which illustrated healthy and cancerous cell and he suggested that groups "go through it [patient's tissue sample] systematically for each sample" to develop some way to quantify their observations for each sample. This introduction occurred during the first 14 minutes of the activity. For the remainder of the time (89 minutes across 3 days) students were observed figuring out how to go about collecting the data and engaging in sensemaking around what they were seeing in the data, and reasoning amongst each other to determine how the data supported their claim.
Lesson 3 - Framing	Instructional moves that supported this framing
Students as data collectors and sensemakers	Jerry introduced the argumentation portion of the lesson by asking the students "what's our question that we're looking at that your going to try and use evidence to support your answer?" A student read out the question and Jerry restated "What caused the colorations and why are we seeing this." He discussed that **he expected students to provide strong evidence for their claim** that does not "just restate the data" and that **students should talk about "what and why" when reasoning about how the evidence supported their claim**. This introduction takes 2 minutes of the activity. During the remainder of the time (58 minutes), students were observed grappling with the data to make sense of why color variations occur in the guppies.

Table 2. *Epistemological Framing of Discussion Following Group Argumentation Activities*

Lesson 1 - Framing	Instructional moves that supported this framing
Jerry gave students the correct answer and identified *the evidence that supported his answer*	Jerry began the discussion **by informing the students** of the "correct answer--that the "unknown organisms were neither a plant nor an animal" but was a eukaryote and two fungi. **He provided the evidence to support *his* claim**. For instance, he said one fungi was a type of mold which could be determined because "the chloroplasts were located around the edge." (4 minutes)
Jerry reinforced the correct answer and indicated that *this answer should be reflected in students' final claim*	Before students began writing up their individual arguments, **Jerry told them they needed to use the correct answers** that he had provided the day before for these reports. He said "You're gonna make a claim… So, **you're not going to write about the claim that you thought you had** before your discussion yesterday." Further, he reminded students of the correct answer for each unknown (e.g., eukaryote), while suggesting their evidence "needs to come mostly from their observations." (3 minutes)
Lesson 2 - Framing	**Instructional moves that supported this framing**
Jerry gave students the correct answer and identified the *correct evidence* to support that answer	Jerry asked students to "get more specific so that they can look at them [the patient tissue slides]." He pulled up the tissue slide for each patient and **told students whether the patient had cancer or not and identified the characteristics of the cells in the picture that supported this answer**. For example, patient 2 was healthy because the cells had "a pretty regular shape." Further, he highlighted that students' were divided on patient 3 so he clarified that this patient had cancer while pointing out the elongated and irregular shapes of particular cells on the slide. (4 minutes)
Jerry reinforced the correct claim and *the reasoning students should use* to support that claim	Jerry reinforced the correct answer by telling students to "**make sure that you have written down that claims for patient 1 and 4 are the ones affected** [by cancer]" to incorporate into their write-up. He then pointed to the abnormal cells on the slide and told students to focus on these for their evidence. Further, he provided the reasoning that students' should use telling them to "**talk about how cancerous cells are not regular/regulated like normal cells, not going through the cell cycle like normal cells**." He further emphasized the correct answer when he stated: "I know it says on our paper to write about your groups claim but **write about the accurate claim**. Patient 1 and 4 have cancer. So, your evidence should support your claim." (3 minute)
Lesson 3 - Framing	**Instructional moves that supported this framing**
Collecting ideas to support *students' as sensemakers*	Jerry began by asking students "**What are some of the multiple trends that you saw**?" He took turns calling on students to present a trend and then he revoiced that student's answer before unpacking it more. (2 minutes)
Jerry gave students the correct answer and *reinforced it* by restating it in multiple ways	**Jerry presented the correct answer to the problem** stating that the characteristic of brightly colored males is a secondary sexual characteristic that "allows them to more successfully reproduce… because in the absence of no predator the colorful males will outcompete the drab males every time." He continued to describe how the colorful males are less successful in the presence of predators. He reiterates these conclusions before stating "fitness is a tradeoff between the advantages and disadvantages of coloration. So, it depends on the other factors around the guppies as whether the coloration is an advantage or disadvantage." (4 minutes)
Jerry reinforced the correct answer and that *this answer should be reflected in students' final claim*	Jerry reinforced the correct answer before students began their individual write ups when he reminded them that he had provided the correct answer the previous day. He stated the answer again saying "**the amount of predators, which was determining the, um, whether being colored was an advantage or disadvantage**. **So, you want to focus your claim on the predator**." (1 minute)

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