

Exploring the Connections Between Epistemic Agency and a Commitment to the Collective Enterprise of Sensemaking in the Science Classroom

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Abstract: Science education reforms prioritize meaningful student engagement in the practices of science, requiring teachers to make shifts in pedagogy that allow for increased student agency in constructing and critiquing science knowledge. However, these shifts create challenges for teachers in engaging students' ideas while also ensuring that they meet established content standards. Models of how teachers can navigate these tensions are needed to help teachers shift their practice. In this study, we investigate three teachers working with the same instructional materials designed to support student agency and examine variations in how they navigate these tensions. We identify how their differential practices around organizing collective knowledge-building may interact with opportunities for students to take on epistemic agency.

Introduction

Scholars and teacher educators are increasingly asking how to engage students meaningfully with science practices so that they become partners in constructing, critiquing, and revising knowledge in the classroom (Ford & Forman, 2006). A key challenge for teachers is to engage students in disciplinary practices in ways that are meaningful to students. That is, in ways that allow students to see these practices as serving their own sensemaking goals (Berland et al., 2016; Manz, 2015). Productive disciplinary engagement is a useful framework for conceptualizing how disciplinary practices can be realized in classrooms (Engle & Conant, 2002). This requires an increasing role for students in developing ideas in which they are accountable to both disciplinary and community norms (Michaels, O'Connor, & Resnick, 2008). They must do so, moreover, in a way that supports the development of shared standards for the knowledge building work within the classroom community that align with disciplinary norms, but that also keep students' ideas at the center (Berland et al., 2016; Stroupe, 2014).

Previous research argues for a framework for instructional materials design, *purposeful sensemaking*, that aims to achieve the balance of engaging students in meaningful science practices that address questions and problems students have identified, while succeeding in addressing target science learning goals (Passmore & Svoboda, 2012; Reiser et al., 2017). Teachers engage students with puzzling phenomena or real-world problems that anchor the unit. Students develop questions they need to figure out and/or identify problems they need to address. Teachers help students work with the questions and problems they identify to develop investigations that help them make progress. Careful selection and sequencing of phenomena and problems, along with teaching strategies that cultivate students' questions and problematize ideas push students to go deeper. This can support students in meaningful science and engineering practices in which their questions drive the sensemaking, yet the balance between cultivating student agency and achieving learning goals can lead to challenges for teachers.

The potential tensions between supporting student agency in today's accountability climate of standards and assessments is a broad problem facing reforms that emphasize involving students in disciplinary practices (Miller et al., 2018). Understanding productive teaching and curriculum design strategies is essential. Developing such a model requires understanding the challenges teachers face in supporting students' agency, variations in how they address these challenges, and how these variations may lead to obstacles or opportunities for meaningful practice for students. To that end, this paper presents an analysis of how three teachers supported purposeful sensemaking in their science classrooms using the same instructional materials. These cases are drawn from a larger study investigating how teachers support students' increasing agency in knowledge building and direction of classroom activities. The aims of the broader study are to explore the beliefs and practices that influence how teachers interpret and enact purposeful sensemaking. Here, we provide analyses of classroom episodes from three teachers who varied in interesting ways. From these cases we then build a set of conjectures about the causes and consequences that can be explored in future work.

Conceptual framework

The contemporary wave of reform in science classrooms requires a shift from “learning about” to “figuring out” (Schwarz, Passmore, & Reiser, 2017), shifting some authority from instructional materials and teachers toward students. The concept of *epistemic agency* has emerged as a key component of this shift — involving students as partners in the intellectual work of building, testing, and revising ideas. Initial studies have explored aspects of epistemic agency that can emerge when teachers provide opportunities, an authentic need, and support for students’ engagement in knowledge building (e.g., Ko & Krist, 2019; Stroupe, 2014).

Another element of the learning environment that can support epistemic agency is to construct science learning opportunities in which students help shape a *collective enterprise* around shared problems and phenomena. This concept of collective enterprise builds on longstanding ideas about the importance of developing a collaborative learning community to build disciplinary knowledge in classrooms (Scardamalia & Bereiter, 1991), and draws on disciplinary discourse practices to explore competing ideas, engage in principled argumentation, and reach consensus (Reiser, et al., 2017). Classroom studies suggest that promoting epistemic agency with attention to the collective enterprise can facilitate student sensemaking. Engaging students in investigations as a learning community, sparked by problems or phenomena that highlight productive disciplinary questions, can help a wide range of students develop more sophisticated science understandings (Penuel et al., 2019). In addition, when a classroom culture is committed to a collective enterprise, students build on one another’s thinking, create shared ideas, and develop communal understanding, although how teachers frame the classroom work can influence how they take up these practices (González-Howard & McNeill, 2019).

We build on these ideas of epistemic agency and collective enterprise by investigating two key questions: (1) How do teachers interact with students to support a collective knowledge-building enterprise? (2) How are opportunities for epistemic agency related to teachers’ support of a collective enterprise?

Data and methods

Our data come from a larger study of teacher learning. Teachers worked with curriculum materials designed to support purposeful sensemaking and participated in professional learning to prepare them to engage students in science practices, and then in a virtual professional learning community supporting enactment in the 2017-2018 school year. In the unit, designing a fog machine motivates students’ investigations of how and why fog forms, helping them develop ideas about particle motion and phase change (Next Generation Science Storylines, 2018).

The three middle school teachers who provided our data teach in a large, urban district in the Midwest. We chose these teachers because of the observable variability in their teaching practices within a particular lesson. Prior to this lesson, students figured out that water in the air can condense on small particles (e.g. dust) to make fog that we cannot see through and explored how these particles get into the air. During this lesson, the classes discuss how temperature influences water particles and if water particles are the only ones influenced by temperature. We focus on the opening whole-class discussions of each class as these offer opportunities to observe how teachers navigate the tension between their plans and students’ developing thinking about a phenomenon.

In this paper, we focus on how each teacher differentially enables and constrains opportunities for collective enterprise and epistemic agency. We identified differences in each teachers’ practices through deductive and inductive coding of recorded episodes. The process began with high-level deductive codes regarding epistemic agency and collective enterprise from the literature. As we applied these codes, we expanded our codebooks inductively in order to more fully capture nuance within each idea. Two researchers individually coded each transcript and then met to reach consensus. Following, the remaining members of the research team coded excerpts from the transcripts and reached consensus to provide further validity evidence for the coding process.

We divide epistemic agency and collective enterprise into two sub-codes: *invite* and *actualize* (Table 1). These codes enable us to tease apart when teachers explicitly refer to or invite the targeted nature of the work (e.g., “we are going to think together”) from teacher moves that support the actual implementation of that work (e.g., “now let’s look at the question you came up with yesterday”). Thus, inviting epistemic agency occurs when teachers encourage students to share their ideas or tell students they will have responsibility for deciding what their findings mean. In actualizing or supporting the implementation of epistemic agency, the teacher *acts* on students’ ideas as they become part of the decision making about the direction and conclusions of their sensemaking. Indeed, teachers may ask students for ideas (invite), but then ultimately tell them what happens next, regardless of their ideas. If students take on epistemic agency, they should be able to recognize the influence of their ideas on the class’s direction and what they figured out. We see these elements varying between episodes. While all teachers had a plan for where they hoped class would go, each handled the opening conversation of the class differently. These differences expose potential variations in the extent to which students’ ideas were used in determining the direction of the class. Thus, we distinguish promises and goals of agency (inviting) from evidence of supporting students in that agency (actualizing). Similarly, inviting collective enterprise includes encouraging

classroom norms for collective knowledge building. When teachers invite collective enterprise, they remind students that they need to listen to one another and put their ideas together. Teachers also indicate they are learning alongside students. Actualization occurs when the teacher acts on these goals to facilitate joint work. This happens when students evaluate their consensus, connect their own thinking with their peers, or when teachers step back and ask students to build directly from one another's ideas rather than filtering ideas through the teacher.

Table 1: Summary of coding scheme for Epistemic Agency and Collective Enterprise

| | <i>Invite</i> | | <i>Actualize</i> | |
|------------------------------|---|--|---|---|
| | <i>Definition</i> | <i>Example</i> | <i>Definition</i> | <i>Example</i> |
| <i>Epistemic Agency</i> | Teacher encourages students to share ideas/lead in conversation | "We need everyone's ideas on the table so we can figure this out." | Teacher uses student ideas to motivate discussion and/or next steps | "You all said we need to investigate temperature next, so that's what we're doing today." |
| <i>Collective Enterprise</i> | Teacher encourages behaviors for collective knowledge-building | "Face this way. It's important that we all hear so we can think together." | Teacher and students accept and take up joint work | "I don't know. I'm figuring this out with you guys. What do you think?" |

Results and discussion

We now present data from three teachers who vary in how they facilitate collective knowledge building and how those differential practices appear to influence opportunities for agency. We present these characterizations in order of apparent attention to collective enterprise to best highlight differences among the teachers.

Case 1: Ms. Falconeri

In this first case, Ms. Falconeri (a pseudonym), encourages aspects of collective enterprise, but plays a directive role in selecting which ideas the class considers, thus limiting the number of students involved in knowledge building and the extent to which students take on agency in framing the progress of their knowledge building. Ms. Falconeri begins by summarizing what the class accomplished previously. Thus, Ms. Falconeri focuses discussion on what she decided was most salient, rather than asking students to characterize what they figured out. Following her recap, she briefly invites epistemic agency with a question:

So, what are we missing? What do we need to think about next? Jagger, can you share what you were sharing with me? What do you think we need to think about next, Jagger?

After an invitation for agency with a question to the class, Ms. Falconeri calls on a specific student to share a specific idea. Jagger suggests the class should consider temperature (which is the prescribed next step in the curriculum). Ms. Falconeri then calls on three other students with their hands up, more invitation for epistemic agency. Two of them also mention temperature. At this point, Ms. Falconeri refers the class to the "Driving Question Board" where the class keeps a record of their questions and acts on the idea she invited Jagger to share.

So it sounds like temperature is something that we feel like we need to investigate, and if I go back to our driving question board over here, I remember a ton of questions saying like what is the ideal temperature for fog to form. ... Um there is a question, how can fog form at 30 degrees and 70 degrees? So we definitely have been wondering about temperature for a long time.

Ms. Falconeri uses the Driving Question Board to direct students to the questions they previously generated. This creates an opportunity for some aspects of actualized epistemic agency, in that the class discusses a question that at least some posed earlier. Additionally, Ms. Falconeri indicates that "we" have been wondering about temperature for a long time in an act of actualized collective enterprise. Here, Ms. Falconeri positions herself alongside students in the knowledge-building process. She then actualizes epistemic agency (students deciding what they think about what happens to the molecules) and collective enterprise (students figuring it out together):

I want you to take one minute at your table, and I want you to discuss what you think happens when water gets hot and air gets hot at the molecular level. Does it change it? How does it change it? What happens? Talk at your tables. Go.

Ms. Falconeri asks the class to act on the idea of temperature. This is actualized epistemic agency in that the next step in the discussion is motivated by student questions, and students take on the knowledge building work of reasoning through what happens to the molecules. One could contrast this with a case where the teacher makes this decision without students by simply telling them to investigate temperature next. Ms. Falconeri retains a directive role by calling on the student (Jagger) who she knew had this idea and directing the class to specific questions from the Driving Question Board, but she also has students work collectively to figure out the question of molecular activity by suggesting the students compare water and air.

When Ms. Falconeri brings the class back to the whole group, she mentions hearing many different ideas from students, but again surfaces one in particular. This interaction stems from student ideas but focuses on one selected by the teacher. In fact, the teacher frames the idea as one that she “really want[s] to test”:

I’m hearing some crazy theories that I’m wanting to test. So, Table 2, Althea had an idea, and I pushed them, and now they have another idea, and I really want to test this idea. So, Althea, what do you think happens to water as it gets hotter?

Althea explains that she thinks molecules move faster when they get hotter, and then Ms. Falconeri asks the class how they could investigate this idea. While this actualizes collective enterprise (asking students for their ideas), and invites epistemic agency (involvement in a decision about how to investigate), it is a limited example since it was the teacher who selected this particular student’s idea as a possible direction.

Does anyone have any other thoughts about that? Does anyone else agree or disagree with Althea? [Anyone want to] provide their thoughts?

After two students voice ideas in response to Althea’s, the teacher steps in:

We’re going to figure out how we can visualize this and I think I have an idea. Althea said that hot water and cold water are moving differently. Right, Althea? You still agree with that? I want to see that. So if you would like to, you are welcome to join on the carpet for demos.

In summary, this case reveals aspects of collective enterprise and epistemic agency. Ms. Falconeri invites students to share their ideas at multiple points during the discussion. She goes beyond simply inviting epistemic agency, in that student ideas were made public and were part of the logic of where the class went. However, while the teacher managed to include student ideas to some degree, she nevertheless played a strong role in selecting the ideas she knew would take the class in the direction she wanted. In addition, there are elements of collective enterprise at work, as students do have opportunities to figure out their thinking together, but the teacher orchestrated the focus for whole-group discussion from the beginning and kept her focus at the center. As a result of the teacher directing whose ideas were heard and her narrowing the conversation to particular student ideas, the collective enterprise was limited, and so was the epistemic agency. There were few opportunities for students to publicly voice their ideas and participate in making decisions about what happened next.

Case 2: Ms. Taub

Ms. Taub opens class by asking students to remind her why the class is doing what they are doing —“remind me why we’re doing this?”—thus actualizing collective enterprise by positioning herself as co-constructor of knowledge with the students (emphasized also by the use of the pronoun “we”). As students share their ideas, Ms. Taub continues to actualize collective enterprise as she offers comments such as the following:

What do you guys think about [what Luke said]? / Can anyone build on his idea? /
Do we agree with what Laura said? / Can someone maybe connect back to Laura’s idea?

In contrast to Ms. Falconeri, where the teacher visibly directs the conversation, Ms. Taub asks students to consider how their thoughts connect with others’. After seven students help the class remember why they are discussing temperature, Ms. Taub closes by summarizing student ideas with an artifact from the previous day.

Great. So yesterday, we created this public record of our ideas, and I summarized them. So we said yesterday that in hot temperature molecules move faster and take up more space, causing them to spread out more than cold water. And in cold temperatures molecules move slower and take up less space than hot water. Do we feel pretty good about what we figured out so far?

Ms. Taub's artifact indicates that she intended for the opening conversation to be about temperature. However, she provides the opportunity for students to identify temperature (or other ideas) and why it should be their focus, rather than opening class with this public record that orients the class toward temperature. This created opportunities for students to voice their thinking and participate in the identification of what the class has figured out so far. The next move in the conversation illustrates opportunities for varying levels of both collective enterprise and epistemic agency as well.

Last night for your homework, I asked if you think that what happens to water also happens to air... Out of everyone who did their homework, 84% of you actually said yes, what happens to air molecules is exactly like what happens to water molecules. And then we had like 16% of those people who did their homework say, no, air doesn't respond the same way. So because we have some discrepancy for what we think happens to particles like air, I asked you for investigation ideas. And I screenshotted them from the Google forms this morning and you gave me some inspiration. So here are our investigation ideas. We're gonna see if what happens to air particles is the same thing that happens to water particles.

In bringing up last night's homework responses, Ms. Taub supports the implementation of collective enterprise. Students can see how their thoughts about the molecules align with their peers' thinking and can identify their ideas for investigation alongside ideas offered by others. Additionally, involving students in deciding how to investigate these ideas supports their epistemic agency. Ms. Taub next leads students in a conversation about which ideas from the homework the class should take up. Although the decision making is focused by the teachers' original prompt (comparing air and water when heated), students participate in making decisions about what investigation to do to resolve the disagreement their collective work identified.

People were saying turn a bunch of fans on, and the air conditioning, try to make it cooler or hotter. People actually talked about confining air or trapping air. Do you think if we just heated our classroom, we'd actually be able to see what happens? Or do you think we would actually need to contain the air?

A student agrees: "Contain the air, because it would take not as long, it would take longer to make the whole entire room a certain temperature than it would be to make a smaller thing a certain temperature." Then Ms. Taub invites epistemic agency by asking students to figure out what they could use to do trap air. One student suggests "Um maybe we could use like a bin", and Ms. Taub invites agency and actualized collective enterprise by throwing the idea back to the whole group.

We could [trap air in a bin]! I don't know. I'm trying to figure this out *with* you guys. Like if we just trap it in a bin, would I be able to see what happens to the air inside if I heat the air?

Ms. Taub positions herself as a learner along with her students, reinforcing the framing of their work as a collective enterprise. Rather than naming an idea she wants to investigate (as Ms. Falconeri did), Ms. Taub refrains from explicitly privileging particular ideas. However, she does endorse the idea of trapping air.

Can we go on [with] this idea though of trapping air? What are some other things that I have in the classroom that maybe could trap air in it that we could like totally see and we know that there's air inside?

Ms. Taub pushes ahead with the student-generated idea of capturing air. A student who had yet to speak suggests a balloon, and Ms. Taub asks why. Indeed, we will soon see that Ms. Taub planned for this conversation to end in students wanting to investigate what happens to air inside of a balloon. Yet in contrast to Ms. Falconeri, rather than explicitly selecting the idea she was looking for, Ms. Taub entertains both ideas of the bin and the balloon. Finally, Ms. Taub reveals her actions and frames them as acting on students' ideas.

There's a lot [of ideas] to try to capture the air, or contain the air. There's a lot of people who had thought let's actually get the air in something. ... So here's the deal, last night when I was reading these, I actually took this [balloon] idea into consideration. I actually did exactly what you guys wanted me to do. I actually stuck the balloon in the freezer. Then I pulled it out of the

freezer, and we're going to see what happens to it. ... I have a video for you of me actually taking a balloon sticking it in the freezer and seeing what happens to it when I pull it out.

Ms. Falconeri and Ms. Taub both planned for students to investigate differences between air and water molecules. Yet in these episodes, Ms. Taub exhibits an increased attention to collective enterprise, and does more explicit work to involve students as epistemic agents. Ms. Falconeri told her students which ideas she wanted them to investigate. Select students had opportunities to share ideas, presumably because Ms. Falconeri considered them most productive. While still constrained by the question in the homework, Ms. Taub allowed more opportunities for students to build knowledge together. She had students compare their ideas both about what they figured out (do air and water behave the same) and how to investigate their questions. The idea of trapping air emerged from students, and she had the class further consider how they might do that. Ms. Taub allowed students to consider alternatives and work out how that would help investigate their question. Thus, her facilitation created more collective enterprise in the enactment, as there were more opportunities for students to share and connect with one another's ideas. The enactment also revealed more epistemic agency, as these conversations enabled more student involvement in more decision points — whether air and water particles behave the same; how to investigate that; and then when trapping air emerged, how to arrange to trap air for the investigation. Interestingly, Ms. Taub had already done the experiment that the class decided on, raising the question of whether that might work counter to students' epistemic agency. The third classroom, while similar to Ms. Taub in some ways, exhibits additional variations of engaging students in collective enterprise and epistemic agency.

Case 3: Ms. Thornhart

Ms. Thornhart opens class by having students respond to a question on their Chromebooks about what they figured out yesterday, so there was a visible record of their responses. After a few minutes for students to think and respond, Ms. Thornhart asks students to look over the other responses to find one similar to their own. Students immediately take up collective enterprise as they read over the responses of their peers. As students share, Ms. Thornhart supports multiple moments of collective enterprise similar to Ms. Taub:

Ok, so who also had something similar to those ideas [air expanding], and what did you say? / Does that sound like what you were saying? / Is there something you want to add or change?

After seven different students share, Ms. Thornhart summarizes the conversation and makes additional moves to support students actualizing collective enterprise. Specifically, Ms. Thornhart asks students to talk in groups to determine what the whole class agreed upon:

Ok, so it seems like at least from the people that I've heard from, we're in agreement. ... Talk to your neighbor. This is what I want you to talk about: based on what you just heard your classmates say, what does it seem like they are agreeing on? ... Talk to your neighbors, and I want to hear from someone that I haven't heard from yet this morning. Go ahead.

By inviting students to talk to one another to summarize class agreement, Ms. Thornhart supports engagement in collective enterprise. In contrast to Ms. Taub, who projected a summary that she wrote for the students, Ms. Thornhart directs students to evaluate consensus and summarize in consultation with their peers. She then follows through by asking two new students to share, thus involving more individuals in the collective work. By this point, Ms. Thornhart has included a dozen students in classroom conversation. Next, Ms. Thornhart makes another move to support her students' engagement in collective enterprise through a classroom vote.

Ok. What do you guys think? If that's making sense to you, thumbs up. If you're like, "No. That's not what I was thinking at all," thumbs down. If you're like, "I'm still super confused and not sure," give me a sideways... I'm seeing mostly thumbs up, so I'm going to jot this down. If I'm hearing you guys correctly, most of you seem to be saying that heat causes the particles to move faster and therefore expand. But not everybody was 100% sure of that, so maybe we can do a little more investigating today. What I was thinking about today might help us with this.

The public voting process allows students to understand more about their collective thinking, similar to the homework responses in Ms. Taub's class and the table discussion in Ms. Falconeri's class. A subtle but notable difference is the framing of the question to students. Ms. Taub and Ms. Falconeri ask students their specific thoughts on air versus water molecules. Ms. Thornhart asks students if their thinking was similar or not or if they

were confused, allowing more flexibility in the forthcoming conversation. Also notable is that Ms. Thornhart indicates that she has a plan for the class today, but it is an afterthought in this comment and not the focus of any of her contributions to the class discussion. Next, Ms. Thornhart invites epistemic agency:

Somebody who is not totally convinced of this, can you let us know what you're thinking so we know what we need to do to maybe get some more evidence?

Ms. Thornhart invites epistemic agency in this comment, motivated by the results of students sharing their thinking. She arrives at this moment of epistemic agency directly out of multiple opportunities for collective enterprise. That is, as students worked out their own thinking and a disagreement emerged, Ms. Thornhart made that the focus of next steps in the discussion. She privileges disagreement and invites students to provide ideas that could help resolve the disagreement. In this way, Ms. Thornhart elicits and draws on students' ideas about what they have figured out to set the direction of the class more extensively than either Ms. Taub or Ms. Falconeri.

As students respond, Ms. Thornhart actualizes collective enterprise similarly to the way she did at the opening of the lesson with comments such as the following:

Any other thoughts about why you're not convinced of this yet? Which is ok. / Does that help clarify for some people who were not sure of this? / Are you still not convinced? Either way is fine, I'm just curious.

We see a stronger focus on collective enterprise from Ms. Thornhart. She stresses comparing ideas with peers, as well as being convinced and reaching consensus. This became a tool to invite students as epistemic agents and to consider how the class could get evidence to resolve the disagreement. Epistemic agency and collective enterprise seem to be supporting one another in these interactions. Next, Ms. Thornhart invites more epistemic agency by asking students to consider other particles they could investigate.

So let's do a little more investigating. So we did this with water yesterday, right? Is there something else that we could explore? Are there other types of particles that might behave the same way or differently that we might be able to look at?

The first student to respond suggests compressing hot water, which contradicts the request to consider molecules other than water. Rather than redirecting, Ms. Thornhart asks why the student wants to consider hot water and writes down her idea, before revisiting her target question.

Ok ok so, so [hot water] might be something we want to explore... let's jot that down so we don't lose that idea. ... I want to backtrack for a second. Because I'm curious, is this like for other things besides water?

Another student suggests air might behave similarly and that they might capture air in a balloon. The student also notes a similar experiment from the previous year. Finally, Ms. Thornhart reveals that she pulled the materials from last year's investigation to revisit it in a new context. As the class discusses this experiment, the students take up epistemic agency since the idea of investigating air molecules in a balloon came from them. This transition illustrates a moment in Ms. Thornhart's class perhaps similar to that of Ms. Taub's. She directs the conversation to considering molecules other than water and mentions that she previously planned for an investigation involving air and balloons comparable to the idea shared by one of the students.

Similar to Ms. Taub and Ms. Falconeri, Ms. Thornhart had a predetermined direction for class that day, but the discussions focused on having students compare their ideas, uncover agreement and disagreement, and try to convince one another. Ms. Thornhart's classroom exhibited the strongest emphasis on collective enterprise among these three cases. This focus on going beyond voting or stating agreement or disagreement to working through areas of disagreement with peers directly led to conversations about what they would need to decide upon. Thus, a focus on resolving disagreement established an emerging need for new evidence. In this way, the need for evidence to resolve their questions created a powerful context for students to take on epistemic agency — determining the next step was in response to their own confusions, disagreements, and arguments.

Conclusion

We have presented three episodes that vary in the support for collective enterprise and epistemic agency in teaching interactions from classrooms using the same lesson and instructional materials. Each teacher invited and

actualized aspects of these elements in their classrooms. However, they differed in how they invited and supported the collective nature of the work and drew on students' ideas. These cases begin to suggest how teachers may vary in their interpretation and enactment of designs intended to support epistemic agency.

These analyses suggest the importance of distinguishing between teacher moves that *invite* students to take up agency and working in a learning community from further moves that *actualize* these promises — “talking the talk” may not always lead to “walking the walk.” These initial cases suggest that teachers who take up these pedagogical goals and invite students' epistemic agency, such as asking for students' ideas about next steps, may still be developing strategies for acting on these ideas and involving students in working through the ideas about where to go next. Although all three teachers had plans for the day, they varied in how much they brought students in as partners in thinking through next steps. Eliciting and leveraging disagreement or a variety of ideas appears to be one way that teachers can not only foster environments committed to collective knowledge building but also support students as epistemic agents in understanding and resolving these disagreements. Prior research documents a need to support teachers as they make shifts to engage students in disciplinary practices in meaningful ways (Berland et al, 2016; Manz, 2015). Examining specifically how in-practice teachers work to make these shifts, and their nuanced differences in enacting curriculum, can help identify successful strategies and avenues to support teacher growth in creating these learning experiences for students.

These analyses also suggest the importance of teasing apart the commitment to participating in a knowledge building community from supporting epistemic agency. Engaging students in connecting their ideas to their peers' with the goal of evaluating and reaching consensus can create opportunities for students to take up epistemic agency and partner with teachers to make progress on those ideas. More work is needed to explore the interplay of epistemic agency and collective enterprise in science classrooms. A limitation in the present study is relying only on evidence from classroom video. In future work, we plan to triangulate discourse analysis with evidence from students' perceptions of their agency and participation in collective knowledge building.

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