Variations in Teachers' Practical Conceptions of Epistemic Agency

Susan Kelly, Nitasha Mathayas, Nessrine Machaka, Jacqueline Chis, and Christina Krist
sbkelly2@illinois.edu, mathaya2@illinois.edu, machaka2@illinois.edu, jchis2@illinois.edu, ckrist@illinois.edu
University of Illinois at Urbana-Champaign

Abstract: While the goal of supporting students' epistemic agency has gained attention in the literature, little empirical research has examined the complex work of teaching involved in doing so. This study examines four teachers' *practical conceptions* of epistemic agency: the images of practice they associate with what "students participating with epistemic agency" looks like. To do this, we interviewed teachers before and after they enacted science units that they had designed with the goal of supporting students' epistemic agency. We present four key constructs involved in teachers' practical conceptions (coherence, flexibility, relevance, and student participation) and show how each teacher uniquely described these constructs in their teaching. This study is a starting point for characterizing the multidimensional work involved in supporting students as epistemic agents, including ongoing tensions that were raised. We discuss the implications of this work for supporting teacher learning.

Keywords: science education, teacher learning, epistemic agency, curriculum enactment

Motivation and significance: Supporting students' epistemic agency

The "practice turn" (Ford & Forman, 2006) in K-12 science education calls for increased student involvement in figuring out key science ideas through participation in science practices. Participating in these practices requires that students take intellectual ownership in developing explanatory science ideas (Berland et al., 2016; Duschl, 2008; Windschitl, Thompson, & Braaten, 2008), including making judgements and decisions about what they know, how certain they are about it, and how to go about figuring out what they still need to know (Ko & Krist, 2019; Stroupe, 2014). We refer to students' ownership in making those decisions as *epistemic agency.*

Supporting students' epistemic agency is pedagogically challenging. Teachers need to take on a role as a facilitator of student ideas, responding in real time to a diversity of ideas that may or may not align with their intended plans (Maskiewicz, 2015). In addition, what it looks like for students to participate with epistemic agency likely differs by grade level, classroom and student context, time of year, teachers' goals, etc. (Hammer, 1997; Stroupe, Caballero, & White, 2018). For teachers, the work of supporting students' epistemic agency involves navigating a significant amount of pedagogical uncertainty in both planning for and enacting instruction.

To date, most empirical work on supporting students' epistemic agency has focused on theorizing what participating with epistemic agency looks like (e.g., Miller, Manz, Russ, Stroupe, & Berland, 2018) or examining how one might design learning environments to support it (e.g. Scardamalia, 2002). Little empirical work has explored the teacher thinking involved in supporting students' epistemic agency: how teachers actually conceptualize, and enact in practice, what it means for students to participate with epistemic agency. Understanding the work that teachers actually do as they take on the goal of supporting students' epistemic agency is a necessary starting point for supporting teacher learning for these ambitious teaching practices.

This paper presents four teachers' *practical conceptions* of epistemic agency: their underlying understanding of what it means to support students' epistemic agency, which we can see though how they act as a teacher and how they describe their teaching. We focus in this paper on the latter: how teachers described their goals and plans for how they hoped to enact a middle school science unit, and their reflections on the unit after teaching it. Our analysis identified four interrelated dimensions that were present in all four teachers' practical conceptions of epistemic agency, though how each teacher conceptualized each dimension in relation to the others varied. We present these variations as a first attempt to characterize the complex work involved in teaching science in a way that supports students' epistemic agency.

Theoretical perspectives: Situated views of epistemic agency, teaching, and teacher learning

Epistemic agency as situated in interaction

Following Damşa and colleagues (2010), we view epistemic agency as an emergent characteristic of a group that allows them to make progress on a shared knowledge object. This characteristic is visible in participants' joint negotiations and interactions. Thus, it is the dynamic interaction between the individuals, rather than traits or

characteristics of any given individual, that reflect epistemic agency. In our view, epistemic agency "lives" in teacher/student and student/student interactions.

Teaching to support epistemic agency

Broadly speaking, we view the work of teaching as setting intellectually meaningful learning goals, then cultivating opportunities for students to interact with each other, with the teacher, and with the material world that allow them to make progress towards those learning goals (Forzani, 2014; Thompson et al., 2016). This work is dynamic in nature and occurs at multiple temporal scales: teachers plan for these opportunities; make moment-to-moment decisions during the course of instruction about how to respond to students' ideas; and reflect on how these interactions will impact future instruction (Colley & Windschitl, 2016; Horn & Kane, 2015).

The work of teaching for epistemic agency adds another layer to this work: teachers also need to anticipate, and make moment-to moment decisions about, how to respond to students' ideas about *where to go next*. This stance adds to the contingent nature of teaching: rather than considering the next activities that might best contribute to students' intellectual growth, it requires considering when and how to involve students in those decisions (Russ & Luna, 2013). Students' ideas about their next steps might be partial and self-contradictory. Thus, we contend that supporting students' epistemic agency requires not only significant interpretive power (Ball & Cohen, 1999) around recognizing the potential generativity of students' ideas for where to go next, but also a repertoire of practices for supporting students in taking ownership over these decisions.

In addition, the work of supporting students' epistemic agency requires pushing back on the power structures present in schooling. These structures inherently convey expectations about the roles that teachers and students play, assigning epistemic agency and authority to teachers rather than students (Apple, 2013; Miller et al., 2018; Varelas, Settlage, & Mensah, 2015). Thus, supporting students' epistemic agency requires an intentional redistribution of power, often involving intentionally opening up dialogic space in classroom interactions (e.g., Hand, 2012). Especially at first, these spaces may be unfamiliar and even risky for students (Ko & Krist, 2019).

Practical conceptions of epistemic agency

Finally, we contend that teachers' conceptions of epistemic agency—the images of practice they associate with what students participating with epistemic agency looks like—influence how they recognize it and adapt their instruction. We term these images "practical conceptions." We consider them *conceptions* in that they are ideas with meanings that are dynamically constituted through interaction and experience over time (see Horn & Kane, 2015). That is, a teacher's ideas about epistemic agency are constantly being shaped and re-shaped as they teach and reflect on that teaching. In addition, we consider these conceptions to be *practical* in the way that Sandoval (2005) and Berland and colleagues (Berland et al., 2016) describe practical epistemologies: understandings that may be tacit, but that guide and undergird activity. In this case, a teacher's conception of students' epistemic agency guides how they attend and respond to students, and how they plan for and reflect on instruction.

Methods

Our work aims to characterize teachers' practical conceptions of epistemic agency in science teaching and learning. We focus in this paper on interview data from four teachers as they planned for and reflected on the enactment of a curricular unit. From these interviews, we characterize the practical conceptions of epistemic agency evident in how they talk about their teaching and identify the key tensions that were raised.

Study context and participants

We recruited teachers from a week-long science curriculum development workshop held in summer 2018. While supporting students' epistemic agency was not a stated goal of the workshop, these teachers self-selected as aiming to support students' intellectual ownership in their classroom. Table 1 describes each participating teacher's background in more detail. During the workshop, teachers revised units that they had co-developed the previous summer. The development process followed a "Storyline" approach (Reiser, Novak, & McGill, 2017). This approach emphasizes coherence from a student perspective and implicitly associates coherence with students' epistemic agency, so we anticipated that the notion of coherence would be a significant part of teachers' practical conceptions of epistemic agency. The participating teachers planned to implement their respective units for the second time in their classrooms during the 2018-2019 school year. Because they had both developed the units and had enacted them at least once in their own classrooms, these teachers had deep familiarity with and ownership over the curriculum materials.

Data collection

We conducted semi-structured interviews with each teacher before and after they implemented their respective units. The interviews were designed to capture broadly the strategies that they used to support students, as well as the specific successes and tensions that arose in practice. During the pre-unit interview, we asked teachers about their background and teaching experience; their motivations for attending the summer workshops; their experiences developing their focal unit; and their enactment anticipations and anxieties for the upcoming year. During the post-unit interview, we asked them to describe how the unit went; any times that students surprised them with what they asked, knew, or wanted to do, and how they responded; any times they felt in-the-moment tensions about where to go next; and what they were most proud of about what happened in the unit this year. Interviews were conducted in person or through video conference and lasted about 40 minutes each. All interviews were video-recorded and transcribed.

Table 1: Participating teachers' backgrounds

Teacher	Years Teaching	Grade	Unit Topic	Geographic Location of School	Additional Experience with Storylines
Sally	2	7	Genetics	Suburb, East Coast	Preservice instruction
Jason	7	8	Cell Development/ Genetics	Rural, Midwest	
Samantha	12	8	Chemistry	Rural, Midwest	
Nadine	15	7	Weather; Cell Development	Suburb, Midwest	Storyline workshop facilitator

Note: Nadine completed two units of instruction and was interviewed before and after each unit.

Data analysis

We adopted a grounded approach to analysis, which we conducted in three phases. First, at least two members of the research team thematically coded each teacher's pre- and post-interviews. Each pair of researchers then crafted a narrative account about each teacher and presented these narratives to the full research team. These narratives helped the research team to identify general patterns across the data, as well as themes that were particular for each teacher. The team then returned to the data, collapsing and consolidating common themes in order distill the patterns reflected across the data. From this synthesis, we developed consensus definitions for four key constructs (Table 2).

Table 2. Key Constructs

Construct	**Definition**
Coherence	The teacher is thinking about the flow of the lessons/unit from the students' point of view, so students are making sense of the content.
Flexibility	The teacher is responding to the students' ideas and modifying the way the content is presented or sequenced to the students. By modifying their own plans, the teacher intentionally makes space for students to engage with the science content.
Relevance	The teacher organizes lessons/unit so that lessons/unit connects with the students' personal experiences or something they are familiar with. The teacher makes the lessons/unit meaningful students and/or supports questions that are more meaningful to students.
Supporting Student Participation	The teacher supports students so that they are positioned to take part in the intellectual work in the classroom in terms of who takes part, how they take part, and whether/if they feel comfortable taking part in classroom activities.

The second phase of analysis involved a constant-comparison approach to coding across the teachers in order to elicit general patterns across the data. We first pattern-coded for the key constructs in a second pass of each interview. We then identified comprehensible segments (partial lines to multiple lines of talk) for each coded instance and created a partially-ordered matrix (Miles and Huberman, 1994) of key constructs by teacher. Segments could be included in multiple construct categories. Each member of the research team reviewed the matrix to evaluate whether the data reflected the construct definition and whether the definitions held up across the data. Disagreements about segment placement were resolved through discussion amongst the research team.

The third phase involved writing thematic narratives and creating diagrams of each teacher's practical conception of epistemic agency. The goal of these narratives and diagrams was to make visible the relationships and directional processes between the key constructs for each teacher and to facilitate additional synthesis of the comparisons between teachers. We are currently conducting member checks for these narratives; any modifications based on these conversations will be reflected in final version of this paper.

Findings

We identified four dimensions of teachers' practical conceptions of epistemic agency: *coherence*, *flexibility*, *relevance*, and *supporting student participation* (Table 2). Sally, Jason, Samantha and Nadine each described these four dimensions as part of their work of teaching while aiming to support students' epistemic agency. However, how each teacher described the dimensions and the relationships between them varied. We summarize the variations in their descriptions as follows:

- Sally and Jason emphasized the centrality of *coherent, relevant* curricula in providing opportunities and motivation for students to participate in agentive ways;
- Samantha emphasized her pedagogical *flexibility* as a means of opening up space for students' epistemic agency; and
- Nadine emphasized strategies for *supporting student participation* as central to her work of supporting students' epistemic agency.

In addition, a few key tensions emerged in teachers' reflections. Specifically, three of the four teachers described tensions between the *coherence* of the unit as written (or lack thereof) and the ways in which they were able to be pedagogically *flexible* (or not); and tensions related to *supporting student participation* often emerged during enactment, which teachers often attributed to a dimension that was initially less central to them.

In the next section, we characterize each teacher's practical conception of epistemic agency. We present a narrative account as well as a diagram depicting the relationships between the four dimensions for each teacher. Solid arrows in these diagrams indicate direct connections that teachers described; dashed lines indicate tensions that teachers identified; and the relative size of each construct indicates the centrality of the dimension in the teachers' descriptions.

Sally: Supporting epistemic agency by planning for coherence in relevant contexts

Sally is a new teacher who had recently completed a teacher preparation program that emphasized a Storyline-based approach to teaching science. Sally joined the summer workshop to continue learning how to develop science units, and despite the fact that her unit (Genetics) was still incomplete, she was eager to enact it. Sally described ***coherence*** as one of her goals for instruction, which she described in terms of making lessons more purposeful: students should understand how investigations followed from each other, and they should understand and utilize classroom tools such as the driving question board. Sally also aimed to accomplish coherence by having student questions be the primary force driving investigations. She discussed tensions from her previous year of teaching in which students asked questions that were personally ***relevant*** to them rather than questions that could drive whole class inquiry forward. For example, students who were twins in her class the previous year were interested in understanding how and why twins occurred. In order to maintain her students' engagement, she had ***flexibly adapted*** her instruction so students could pursue individual investigations.

After enacting the unit, Sally reiterated how having purposeful investigations had helped students see ***coherence*** in her lessons and drive investigations forward through their questions. Sally was surprised to see that students' questions had changed from scattered and personal towards focused and concept-relevant over the course of the unit, attributing at least part of this shift to coherent lessons that led to deeper conceptual understandings. This change also helped her reconceptualize ***relevance***. In addition to being about connections to students' personal lives, Sally described how the unit could also become relevant with a genuinely engaging anchoring phenomenon.

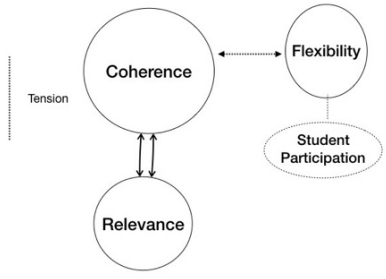

Figure 1. Sally's practical conception of supporting epistemic agency.

Taken together, Sally's practical conception of epistemic agency could be described as follows (Figure 1): *Planning for coherent and relevant instruction supports students' epistemic agency. Specifically, when teachers select anchoring phenomena that are relevant to students' lives and that are genuinely interesting, students will develop deeper conceptual understanding. Students then sustain agentive participation when investigations are driven through their concept-relevant questions.*

Jason: Supporting epistemic agency by making science relevant and accessible

Jason is a second-career teacher in his 7th year of teaching at the time of data collection. He was a big proponent of the Storyline process because it allowed him to teach in a way that meshed well with his natural style. Jason centered his teaching around developing ***coherence*** for students through ***relevance***. He described several instances of efforts to teach using examples that were familiar to students, indicating that making connections to something they know "carries the students a bit further." However, he also described how the tight coupling of coherence and relevance could also lead to tensions because students might assume they already understand the phenomenon and would not be curious to drive investigations. Jason felt the tension between students' "exhaustion with the topic" and "solidifying" what students know by using a familiar subject. As a result of this tension, Jason decided to enact what was originally the Genetics portion of the Cell Development unit using a different phenomenon: their classroom pet, a genetically modified fish that glowed under UV light.

Jason noted that teaching the unit for the second time meant that he himself better understood the unit's ***coherence:*** the flow of the unit and how the lessons built on each other. Because of this, he was better able to ***support student participation.*** However, his own familiarity also led to another tension: when he was more familiar, he taught with greater pedagogical ***flexibility***; and sometimes within this flexibility he struggled to structure conversations "without putting too much in or giving too much away" to students. He described how he sometimes unintentionally impeded students from doing the intellectual work: "I stumble over my words and walk right into what we're going to do next. And then I'm like 'Oh, you guys were supposed to do that, not me."

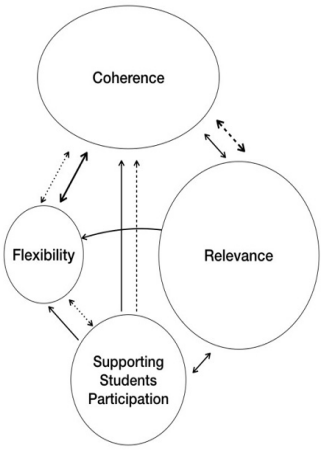

Figure 2. Jason's practical conception of supporting epistemic agency.

An ongoing and related tension for Jason was how to ***support student participation*** in class. He noted that he often decided to "run with student ideas," and he emphasized that encouraging multiple avenues and modes for students to enter into the conversation was central to his teaching. He had a high number of students with individualized education plans (IEPs) and was committed to finding ways to involve them in his classroom community. He described how his classroom Instagram account, where he shared photos from his life of phenomena that related to what they were learning about in class, was a place where "a vast majority of my [students with IEPs] jump in and participate where they wouldn't normally in class."

Taken together, Jason's practical conception of epistemic agency could be described as follows (Figure 2): *Science contexts that are relevant for students support student participation. When coupled with a teacher's sense of coherence, the pedagogical flexibility to run with students' ideas, and multiple entry points and modes for participation, students can begin to shape the course of the lessons.*

Samantha: Supporting students' epistemic agency through flexible and responsive teaching of relevant topics (if lessons are coherent)

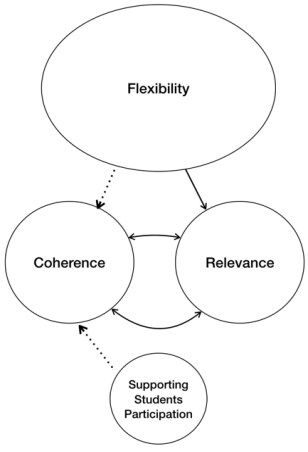

Figure 3. Samantha's practical conception of supporting epistemic agency.

Samantha is an experienced teacher who became actively involved in science curriculum development when she switched from teaching English to exclusively teaching science seven years ago. Her own pedagogical ***flexibility*** was a defining feature of how she described her teaching, both generally and in terms of her goals for the Chemistry unit. Samantha described her desire to cultivate a space in which students' curiosity and questions related to content would drive the course of the unit, describing how she often would "go rogue" (i.e., deviate from the written curriculum materials and her own plans) and follow students' ideas. For example, she recounted how in the previous year she spent a significant amount of time on unplanned investigations of bubbles and surface tension in response to students' questions.

However, after enacting the Chemistry unit, Samantha reflected on a variety of factors that impeded her pedagogical flexibility this time. For instance, the timing of the science fair and an extended winter vacation interrupted the Chemistry unit in inconvenient ways, putting time pressures on her willingness to "go rogue." This lack of flexibility made it difficult to develop a sense of ***coherence*** for students.

As a result, Samantha placed more emphasis on ***relevance*** as a strategy to maintain coherence in the day-to-day enactments, trying to "use real world

applications of things." In addition, she reflected on how the lack of relevance of the anchoring phenomenon for students made developing ***coherence*** difficult and also impeded ***student participation***: while she had changed the anchoring phenomenon from an "elephant's toothpaste" reaction to an exploration of how babies are kept warm in incubators without electricity, she noted that this anchoring phenomena still needed adjustment. Specifically, students did not generate questions when shown data about baby incubators that led to productive investigation ideas. As a result, their subsequent investigations felt contrived and disconnected from their eventual engineering activity where they designed incubators heated through chemical reactions. In other words, the unit lacked a sense of ***coherence*** for students.

Taken together, Samantha's practical conception of epistemic agency could be described as follows (Figure 3): *Flexibility in responding to students' ideas allows them to drive the investigations. However, for this to occur, the unit needs to be motivated by a relevant context about which students generate questions that motivate investigation ideas. Without this sense of coherence, students may not participate in meaningful ways.*

Nadine: Explicitly and continuously supporting student participation is necessary for epistemic agency

Nadine is an experienced teacher who has taught science and remedial math at three different middle schools in addition to working as a science instructional coach and professional development facilitator. Nadine's efforts to ***support student participation*** were a core commitment guiding her instruction. She particularly aimed to create a learning environment in which students felt safe and empowered to carry the conversation. She described how she wanted each student to "feel as comfortable as the other one who feels that they know it all, and help that student who thinks they know it to realize, wait, I could push my understanding and make it more accessible to everyone." She was particularly interested in making students more aware of who was and was not participating and described many strategies for making participating more visible, including using a talking stick and making a map that tracked speakers during a discussion.

Nadine's consideration of ***coherence***, ***relevance***, and ***flexibility*** fell within her attention to supporting student participation. For example, Nadine expressed the need for the unit to be ***coherent*** for students such that they "know where we're going, and that it's not my unit teaching them." She also developed and modified activities to make them more ***relevant*** to the students because the familiarity supported their ability to be the ones driving the unit. For example, the anchoring phenomenon for the Weather unit was initially an examination of weather patterns at case study sites around the world. Because this was not particularly engaging, the following year she changed it to hurricanes. This phenomenon was more engaging but too complicated to be fully explained. Nadine again changing the anchoring phenomenon to hail—an event more familiar to her Midwestern students, and explainable using the unit content.

Nadine leveraged pedagogical ***flexibility*** strategically, modifying her instruction in the day-to-day in ways that intentionally supported her goals for ***relevance*** and ***coherence***. She described her goal for flexibility as prioritizing students sensemaking. For example, during the Cell Development unit, Nadine modified a lesson that initially required students to use a microscope. She chose instead to use a video that each student first viewed individually on an iPad so they could "watch close up and know what they are looking for." They then watched the video as a whole class so "we could pause and point things out and ask questions." Nadine also described how she decided to be flexible in following students' lines of inquiry in the moment: she would "usually kind of go down that hole with them, because I feel like that gives them a better snapshot of science than me saying, well no, I think we should do this." While there are clearly a complex set of values and goals undergirding Nadine's instructional decision-making that go beyond the four we have identified here, we see her approach to flexibility as impacting the relevance and coherence of her unit.

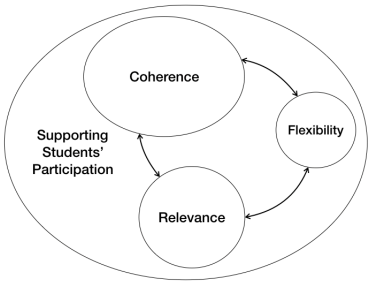

Figure 4. Nadine's practical conception of supporting epistemic agency.

Taken together, Nadine's practical conception of epistemic agency could be described as follows (Figure 4): *Students participate with epistemic agency when their classroom culture fosters that participation around content that is relevant to them. By flexibly supporting student sensemaking, students enact coherence themselves as they seek to ask and answer their own questions.*

Conclusions and implications

Through interviews about the enactment of a curricular unit, these four teachers expressed practical conceptions of epistemic agency that coordinated coherence, relevance, flexibility, and supporting student participation. The

consistency of these four constructs across the teachers is notable given their varied levels of teaching experience, but perhaps not surprising: coherence was heavily emphasized as part of the unit development process during the summer workshop, and the other three constructs have overlaps with broad themes in the research literature underpinning the Next Generation Science Standards. At the very least, the consistency of these constructs suggests that these teachers are "plugged in" to current reform efforts in the US and are actively wrestling with how these constructs work together in practice to support students' epistemic agency.

There were also substantial variations in how these teachers emphasized and connected these constructs. Sally and Jason leaned most heavily on the role of the *curricular design*, describing the inherent coherence and relevance of the designed materials as central to supporting students' epistemic agency. Samantha's experience demonstrates how necessary coherently designed materials are. In contrast, both Samantha and Nadine foregrounded elements of their *pedagogical practices* as central in supporting students' agency. This difference is perhaps a reflection of experience—both Samantha and Nadine had done many years of curriculum design prior to the summer workshop, whereas Jason and Sally were newer to it and were working with a partially developed Genetics unit. As a result, they may have been in "design mode" as they were teaching, perhaps leading them to reflect more heavily on the design of the unit itself during our interviews than their lived enactment of it. Regardless of the cause, this variation highlights the need for both quality curricula and nuanced instructional practices for supporting students' epistemic agency.

It also seems that that the connections between these constructs become more complex with additional years of teaching experience. Sally, the newest teacher, was just beginning to wrestle with some of the tensions between the curriculum as designed and the in-the-moment flexibility required for enacting it. In contrast, Nadine, the most experienced teacher, used the curriculum-as-designed almost as simply a platform upon which she could work to develop student relationships and participation norms, recruiting coherence, relevance, and flexibility in nuanced and strategic ways over the course of her instruction.

Within this sample, Jason and Samantha seem to represent teachers who are developing increasing complexity of practice. These developments are evidenced in the tensions that they each described. Samantha wholeheartedly adopted the flexibility required of responsive teaching, desiring for her students to be the ones taking the lead and doing the intellectual work. Yet the lack of relevance (and consequently, lack of coherence) of the unit made it difficult for her to enact these pedagogical practices, and students' participation suffered as a result. In our continued work with Samantha, she identified explicitly supporting student participation (through norm-setting, self-reflections, active listening activities, etc.) as a key goal for her during the current school year (2019-2020). Similarly, though the bulk of Jason's discussion about his unit centered on the design of the unit itself and his own wrestling with its coherence, he expressed a continuous commitment to attending to the uniqueness of his individual students and described creative attempts to diversity the ways that students could choose to participate. It seems that Jason may be in the midst of experimenting with which supports for participation create the best avenues for students to take intellectual ownership in his classroom.

This emerging emphasis on supporting student participation underscores the discomfort and potential risks that opening up dialogic space in classroom interactions presents for students (e.g., Ko & Krist, 2019; Hand, 2012). It also raises important questions about *who* gets to participate, and *how*. Our interviews did not ask teachers to discuss their conceptions of equity, which we know to be at least as complex and dynamic as epistemic agency (e.g., Philip, 2011). This study suggests that a focus on teachers' conceptions of epistemic agency necessitates a focus on teachers' conceptions of equity as well. In other words, what does *equitable* agentive participation look like, and how do we support it?

Our ongoing work examines observations and interviews with teachers during the enactment of these units, allowing us to couple what teachers actually do in practice with what they described. We aim to then use these understandings to inform the design of professional development experiences for teachers that support them in regularly (and equitably) supporting students' epistemic agency.

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