Epistemic Agency as a Members' Experience

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Abstract: We present a conceptualization of epistemic agency that centers attention on participants' experience as a central identifying criterion, including the powered nature of inquiry. This allows us to examine *how* and *by whom* the inquiry is defined, navigated, and reified. We draw upon the existing conceptualization of *inquiry as a members' phenomenon* to attend to how key epistemic moments—beginnings and endings—allow us to recognize learners' competence in defining and shaping knowledge products. We take this as an opportunity to sensitize ourselves to issues of power and equity in STEM learning spaces. We argue that viewing *epistemic agency as a members' experience* sensitizes researchers and educators to collaboratively decide with learners (rather than for learners) what counts as making progress and identifying paths within and through STEM learning environments.

Introduction

One of the key challenges of the "practice turn" in US science education (Ford & Forman, 2006) is supporting learners' participation in science and engineering practices, particularly with respect to knowledge building. Informed by research on learning environments that turn over varying degrees of knowledge-building responsibility to students (e.g., Calabrese Barton & Tan, 2010; Engle & Conant, 2002; Scardamalia, 2002), most scholars agree that epistemic agency is a key goal underlying these reforms (Berland et al., 2016; Duschl, 2008; Stroupe, 2014; Windschitl, Thompson, & Braaten, 2008). Existing characterizations of learners participating with epistemic agency often position learners to negotiate paths forward within ongoing inquiry by engaging with the substance of ideas (e.g., arguing that a model of air should include empty space between particles) or navigating investigations once begun (e.g., deciding what roles each group member will take on to conduct an experiment). In contrast, we wish to examine how learners negotiate the context of the inquiry itself: how students and youth negotiate satisfying beginnings and endings to inquiry (e.g., orienting to a new shared puzzle as worthy of investigating, coming to consensus that as explanation is satisfactory). Here we draw on Schegloff's (1992) context—an understanding of participants' activity that participants' themselves show to be relevant during interaction—in this case how participants show they are orienting to their activity as a moment of inquiry. We also examine negotiations with series of moments in inquiry pathways. We argue that attending to negotiations across moments and pathways sensitizes us to issues of power and equity as we wrestle with how to productively support students' agentive participation in science knowledge building.

In this paper, we present a conceptualization of epistemic agency that centers our attention on the experiences of participants as a central identifying criterion. This allows us to examine *how* and *by whom* the moments of inquiry are defined, navigated, and reified. We begin by drawing upon a framing of *inquiry as a members' phenomenon* (Keifert, 2015; Keifert & Stevens, accepted) as a lens for exploring critical moments in inquiry: interactional beginnings and endings. We use this lens to examine two examples of students beginning and ending inquiry on their own terms (over and against their teachers' plans). We build a conceptualization of *epistemic agency a members' experience* (EAME). This conceptualization prepares us to recognize participants' competence and create space for transformative outcomes. We intend this conceptualization to be drawn upon as a lens not only at the scale of particular interactions (as members' phenomenon is bound), but also at broader scales of activity across learning experiences. As a result, we see the value of EAME in presenting a view of learning where learners' experience is the center of educators' and researchers' attention for deciding what counts as meaningful participation in scientific work. This re-positions all learners, but particularly those historically disempowered in STEM spaces, to use science as a tool for their own learning and purposes.

An interactional definition of inquiry as a guiding lens for epistemic agency

We begin by briefly presenting *inquiry as a members' phenomenon*—IMP (Keifert, 2015, Keifert & Stevens, accepted). IMP helps identify where "productive scientific work" might be happening by recognizing how participants orient to their activity as inquiry. Specifically, we examine beginnings and endings as key moments in any interaction (Jordan & Henderson, 1995). These moments illustrate how *participants* jointly negotiate what it is that is worth working on together, rather than looking for interactions that fit an *a priori* description of doing science or inquiry, such as characterizations of argumentation or experimentation. Importantly, this lens is not

meant to replace such characterizations or to negate the importance of accountability to the discipline for something to "count" as doing science. Instead, this lens is meant to highlight what may be otherwise overlooked dimensions of the data: it focuses our attention on what participants do that signals productive work *to them*. We draw upon IMP in the analysis of two moments of inquiry (in a middle school classroom and undergraduate physics course) to examine how students' experiences with shaping inquiry in beginnings and endings tell us about what counts as meaningful, agentive scientific work to them. This analysis in turn helps us to develop *epistemic agency as a members' experience*, a conceptualization we find fruitful at multiple scales.

Inquiry as a Members' Phenomenon (IMP)

To identify participants' perspectives about what counts as productive work to them (Sacks, 1967/1992; Stevens, 2010), we draw on a definition of inquiry developed through interactional and ethnographic analyses of video data of everyday interaction (McDermott, Gospodinoff, & Aron, 1978; Jordan & Henderson, 1995). These analyses characterized patterns of *beginnings* and *endings* of joint exploration, as well as the ways that children made progress during inquiry as they drew upon a variety of sensemaking resources. Figure 1 represents these patterns as a prism. The definition of inquiry synthesized from these patterns emphasizes (1) how participants come to begin inquiry as they orient to a shared puzzle, (2) the sensemaking they engage in to make progress in inquiry, and (3) how they end that inquiry as they orient to ending in a manner satisfactory to them.

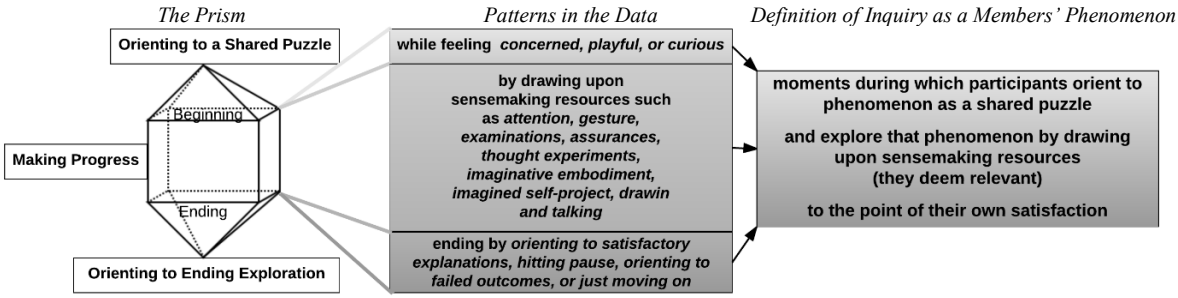


Figure 1. The prism of Inquiry as a Members' Phenomenon (Keifert & Stevens, accepted).

An IMP illustration: Caroline, Momma, and the Fog

We present a brief example drawn from this data corpus to illustrate how IMP shows up in interaction and guides our attention to what participants consider to be important and productive work. This example comes from video of Caroline (5y 11m) and Momma at breakfast. Caroline worked to initiate a joint exploration around the fog she noticed outside. Caroline turned her head to the front of the house, then called "Hey Momma" and pointed towards the front of the house, wiggling her hand and adding "Outda window?" in a concerned tone. She then asked, "Why is it so smoky?" After she saw Momma looking out a different window, she repeated this pattern. Caroline's 'winding up activity' (Jordan & Henderson, 1995) carefully coordinated Momma's attention through talk, gaze, and gesture before she uttered her first question. The range of material and interactional resources she drew upon to coordinate this activity provide indicators that exploring this shared puzzle was important for Caroline.

Ending their joint interaction around the "smoky" also required coordination of material and interactional resources. After walking out the front door to examine the fog more closely, Momma returned and explained to Caroline, "I think it's just fog...like clouds that are way down low...just blowing by." Momma oriented to this as a satisfactory explanation for her by turning away to talk to Caroline's sister. However, after Momma turned away, Caroline asked, "But, has it done that before?" pressing for further explanation. In response, Momma reoriented to their exploration. She explained that while it "doesn't happen very often here," "it's nothing to worry about…[it] happens to be what the weather is today...kinda of low level- low layer of fog". In response, Caroline turned her attention elsewhere, indicating her satisfaction. In this episode, Caroline and Momma jointly achieved a satisfactory ending only when both oriented to Momma's explanations as satisfactory. Similar to 'winding up' efforts, these 'winding down' efforts indicated what kind of explanation was satisfactory for Caroline.

This moment illustrates what we mean by jointly negotiated; it highlights Caroline's work to achieve shared attention with Momma, their shared exploration of the fog, and efforts to achieve a satisfactory resolution. It also highlights that even very young children like Caroline, age five, take such puzzles seriously as worthy of exploration. This focus on the relevant puzzles and satisfying explanations aligns with recent work emphasizing affect as inherent to inquiry (Jaber & Hammer, 2016; Manz 2015) and work that recognizes children's diverse sense-making resources (e.g., Nasir, Rosebery, Warren, & Lee, 2006). As an endogenous representation of

inquiry, IMP focuses on learners' experience, supporting researchers and designers to explore inquiry pathways with learners in ways that allow joint determination of what counts as important and productive scientific work.

Looking for epistemic agency in interactional beginnings and ends

Using IMP to identify moments of productive scientific work helps us decide where to look for the epistemic agency that matters in terms of shaping participants' experiences of making decisions about beginning and ending knowledge-building interactions. After identifying these interactional beginnings and endings, we then sought to characterize how epistemic agency shows up in those interactions. Rather than viewing epistemic agency as a trait or characteristic of an individual, we draw on Damşa and colleagues (2010) interactional conceptualization of epistemic agency as *shared,* emergent through "collaborative activities aimed at the creation of shared knowledge objects" (p. 146). In addition, we use Gresalfi et al.'s (2009) operationalization of "agency" as actions (or refrains from acting) that impact the joint activity of a group. When we add "epistemic," we focus in on actions (or refrains from action) related to knowing and knowledge-building. For example, the choice of using a black pen over a blue pen may be an exercise of agency, but typically not one of epistemic agency. However, if that choice is accompanied by a conversation about how water molecules and air molecules are two different things and should be represented differently, then that choice becomes an exercise of epistemic agency.

We are also explicitly interested in *young peoples'* epistemic agency—that is, in understanding how it is that students and youth act in ways that substantially impact collaborative knowledge-building activity in science. This activity often occurs in settings where students are the "novices" and adults are considered the "experts": K-12 schooling, university classrooms, or programs for youth involvement in professional science labs. Structurally speaking, the bulk of the substantive epistemic decision-making is the responsibility of these expert adults. Therefore, any actions on the part of students and youth that have an impact on their shared knowledge building are the result of a re-negotiation of epistemic responsibility and of power. We examine such instances next.

Epistemic agency in inquiry: Images of some ideal cases

We present two examples illustrating young people's experiences in substantially negotiating the beginnings and endings of inquiry: their epistemic agency. Examples come from studies conducted in a variety of settings (K-12, university science classrooms) with diverse participants (middle school-young adults). Each vignette represents a substantial re-negotiation of epistemic responsibility and power in ways that allowed learners to be the primary decision-makers at critical points of their inquiry. We use them as vision-casting illustrations: they are not meant to be representative, but instead were intentionally selected to provide concrete cases that expand our notions of what it means to fully embrace reform-based goals of engaging students meaningfully in science practices.

Beginning by identifying and articulating problems

We begin by exploring students orienting to a shared puzzle at the beginnings of inquiry and at pivot points toward new lines of investigation. Determining what is cause for inquiry is a significant epistemic accomplishment. This example comes from a study which identified exemplar moments of students' seeking coherent, causal explanations of the natural world and to identify themes and patterns across these cases (see Watkins, Hammer, Jaber, Radoff and Phillips, in press; Phillips, Watkins and Hammer (2017). In all cases, students did work to identify, articulate, convince others of inconsistencies or gaps in their understanding, which we refer to as problems or puzzles. In most cases, this process was a primary dynamic, sustained for several minutes and involving multiple participants. In this way, we see this work of orienting towards a shared puzzle as important to the students' experiences of engaging in inquiry. These shared puzzles become student-created knowledge objects. In no case was this an explicit goal of the instructors; rather the importance of problems as knowledge objects emerged spontaneously within classrooms that fostered epistemic agency.

To illustrate this point, we present part of an episode from a discussion section within a college physics course. During the previous day's lecture, students discussed a homework question: Does an escalator do more, less, or the same work on you if you walk up or stand still as you go between floors? Most students answered that the escalator does more work. After some discussion about each option, the instructor had given students the answer—the escalator does less work on you when you walk—and moved on. In a recitation section the next day, the TA noticed that students were still discussing the question. She abandoned her previous plans and asked students instead to share their thinking about the question. A student, Pat, struggled to articulate her confusion.

> Pat: I was saying if we're- Well, if you're walking up the escalator, doesn't the escalator do-well we already know it does less work on you but, like, if for that time, you're still moving up, you're moving up at a constant rate so it's not changing the amount of- wait, ok let me try to articulate this.

TA: Ok. (6.0 second pause)

Pat: Well, when you're walking- no, the escalator isn't doing more work on you while you're walking up for the same argument that we said in class where it was like, your feet is always on the ground, so the same amount of weight is always on the ground, so therefore the escalator is always exerting the same amount of force on you. But if you're jumping for example, then that means that the amount of force the escalator on you- is doing on you, changes (inflected up).

TA: So, if you're jumping, or I would argue, even walking…

Pat: No, if you're jumping on the same step, and you're moving up an escalator, for example,

TA: Oh, if you're jumping on the same step.

Pat: (Overlapping) [Same step]. So, in that case, wouldn't the escalator be doing more force on you, compared to if you're standing still?

(A) Pat pauses for six sections

(B) Pat gestures as she says "jumping on the same step"

Figure 2. Pat explains (left, front) works to articulate her question.

Within a brief back and forth with the TA, Pat clarified that her question was about what happens if you jump up and down on the same step as you move up the escalator (Figure 2). Other students then took up this question, driving a new round of discussion around the concepts of force and work. There was still something bothering students, including Pat, about the original homework question. There was still a problem, even though they knew the correct answer to the original question. Pat's achievement in this moment was not constructing an answer or explanation; it was constructing a new question to address her confusion about the earlier question and answer.

We see students' epistemic agency, not only in the sense that they had control over the topic they pursued, but also in the sense that they had the authority to decide whether or not there was a puzzle. In this episode, we see Pat's contribution sparking renewed engagement around the ideas of work and force. In other cases, we see students' work to articulate their confusion and construct problems sparking new lines of inquiry and sustaining students' engagement (Phillips, et al 2017; Watkins, et al, in press). We see a complementary response of the educator, allowing Pat and the students the time and power to determine for themselves (at the cost of her lesson plan) a problem worth pursuing. By attending to this beginning, we see how students shifted what counted as open for inquiry, thereby determining for themselves (and with the support of their instructor) a context for inquiry.

Ending inquiries by listening, empathizing, and changing one's mind

We now explore how shared epistemic agency shapes *ending* inquiry. This example comes from a study that observed middle school science classrooms to examine students' participation in science practices developed over three years (Krist, 2016). We present a moment when middle school students *oriented to a satisfactory ending to exploration, by their own terms*; their experience was one in which they had the power to decide their inquiry was done, and they took on the responsibility to get everyone (including the teacher) on the same page about it.

During the last few days of an earth sciences unit exploring plate tectonics, Mr. M's 8th grade class was trying to figure out what kind of plate interactions were forming the Andes Mountains in South America. They initially claimed that they were caused by oceanic- continental subduction, when an oceanic plate moves towards and underneath a continental plate, but they noticed two key details that made them question this claim: the trench (a key feature indicative of subduction) was slightly west of the South American coastline; and the South American plate itself was much bigger than South America, meaning it was covered about equally with ocean and continent. These observations led to a several-minutes-long discussion about how they would define whether the South American plate was oceanic or continental.

Before they had reached a decision, Logan asked why it even mattered that they decide which kind of plate it was anyway, eventually proposing that all plates are an alloy-like mixture of basalt and granite:

Logan: Why can't it just mix together? Like, to make bronze we, we've got to mix copper and tin together. Nah, I'm ser–this is on point? [...] No, look, to make something else,

you've got to mix two things together. You get that, right? So why can't the plates just like, mix together and then they make like a super-plate?

This idea was highly contentious, and became more heated as Logan drew out his idea on the board and labeled one melting plate as "oceanic" and one melting plate as "continental" (Figure 2). Several members of the class insisted that his labels were a problem, but Logan argued it did not matter what the labels were. There was a lot of cross-talk in response, with several students voicing their opinion that his idea could not work. In the midst of this milieu, Amy, who had been quiet, clarified why Logan's model did not work:

Amy: I think what I'm trying to say is that like, it wouldn't make sense because isn't the oceanic plate like, less dense? I mean--

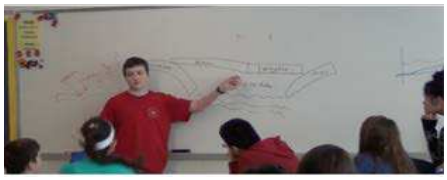
Logan: No. The oceanic's more dense.

Multiple speakers: [*Unintelligible*] why is that? [*Several voices*] Why is that one there?

Mr. M: Okay, then – I want, I want just Amy and Logan, no one else, for the next minute.

[*Several voices; Amy says something inaudible to Logan*]

Logan: I get it [*erases board*]



(A) Logan's model of mixed plate materials.

(B) Logan after erasing his model and explaining what he "got" about plate density.

Figure 3. Images representing students' discussion.

As Logan erased the board, Mr. M exclaimed, "I don't get it, what's this—Wait, ah—ha?!?" He jumped forward from where he had been in the back of the room, sat at a table in the second row, and raised his hand. Logan gestured for him to speak, and Mr. M said, "I don't get what you just got. Can you say it slowly?" Logan explained that the differences in density in the plates meant that the continental plate could not go under the oceanic plate. Mr. M responded, "Okay, I missed that. So something was mislabeled or something?" While Mr. M struggled to understand why Logan had thrown out his entire model, Courtney summarized for Mr. M that in light of Amy's idea, only one type of plate could go under the other; so then if the Andes were formed by subduction, the South American plate would have to be continental.

This "ending" of the inquiry was catalyzed by Amy's simple, and mostly inaudible, comment about plate density. She made this comment after listening to Logan's idea and others' critiques of it and pinpointing a piece of information that he was missing that convinced him to change his mind. While Mr. M saw this "resolution" as a decision about the labels on Logan's model, which perhaps they could continue tweaking, Logan and Courtney saw it as an *ending of an exploration* around Logan's idea. This case highlights how students pushed back upon the power structures of schooling in that they move the teacher to their satisfaction despite his expectations/plans. It is important to note, however, that the work they are doing is different than conceptualizations of students' *resistance* in the classroom, or intentional non-participation, often in opposition to a teacher's wishes (e.g., Hand 2010). In this case, the teacher and students were on the same "team," so to speak; through their negotiation, he was eventually brought on board with their experience of a satisfactory ending.

Epistemic agency as a members' experience

These two examples illustrate *epistemic agency as a member's experience* (EAME). Our brief analysis illustrates the interactional accomplishments involved in orienting to beginnings and endings to inquiry and in substantially shaping the nature of those beginnings and endings. This prepares us to recognize the importance of empowering learners to make critical epistemic decisions in key moments such the negotiation of beginnings and endings to inquiry that fundamentally influence subsequent inquiry pathways. In this way, EAME also helps us attend to issues of power and potential transformation across the process of inquiry. We now draw upon EAME to explore learners' transformation of inquiry paths across the scale weeks engagement in an informal learning environment.

Using *Epistemic Agency as a Members' Experience* as a lens to understand youths' transformation of inquiry paths

Drawing upon *epistemic agency as a members' experience* (EAME), we attend now to the impact of histories of power and exclusion in STEM spaces by considering how membership interacts with epistemic agency. Specifically, we draw upon EAME to sensitize us to the contexts learners create (and re-create) for inquiry when they are positioned as epistemic agents throughout the process of inquiring. Considering how people can participate with epistemic agency raises questions not just about the nature of participation but also the goals.

For the purposes of this paper let us consider the concept of making progress through the prism of IMP in Figure 1 (above) by leveraging data at a different scale. Making progress through the prism can be thought of as either potentially benign participation trajectories, or as a set of powered interactions (Esmonde & Booker, 2017). In this case we explore two types of trajectories for youth participating with epistemic agency: a) inclusive and b) transformative (Scipio, in preparation). Inclusive epistemic agency refers to the ways in which youth were able to feel like knowledge creators within existing STEM participation frames (Stroupe, 2014). Transformative epistemic agency refers to the ways in which youth are able to transform science learning spaces to more closely resemble their own ways of knowing and sharing expertise across the longer pathways they navigate through learning experiences. We present here a brief characterization based on extensive ethnographic analysis (Scipio, 2015) to illustrate inclusive and transformative epistemic agency.

Inclusive epistemic agency is built upon work that draws links between everyday science and canonical science practices (Bricker & Bell, 2014; Toomey Zimmerman & Bell, 2014) making it clear that youth can participate in disciplinary ways. While this work repositions youth as knowledge holders and developing experts, these descriptions may also sensitize us to evaluate youth participants' *competence* only in relationship to disciplinary practices. Using examples from youth participating in a chemical oceanography out-of-school time (OST) broadening participation program (Scipio, 2015), we can see how powered relationships to disciplinary expectations can shape youth participation trajectories. The OST program was a collaboration between two youth-serving environmental education programs, a chemical oceanography laboratory, and a learning sciences research laboratory. Youth in the program learned about fish feminization in the local body of water and designed their own research project to leverage the chemical oceanography laboratory's resources to answer their own questions about water quality. The youth in Scipio's study participated in the full practices of the collaborating laboratory. They learned how to "make progress" in ways that mapped onto canonical expectations—they collaboratively designed and conducted a research study, they made a poster, and they presented their work at an international conference. As such, their epistemic agency and pathways through the prism were directly related to canonical definitions of STEM participation (similar to the hypothetical students in the classroom in the introduction).

This leads us to ask questions about EAME informed by Megan Bang and Shirin Vossoughi's questions (2016) about designs in the learning sciences. In particular, can students have experiences in which their decision-making involves "productively disrupting historically powered relations as part of working towards equity and forms of just democracies" (p. 173)? Aiming for such versions of epistemic agency is particularly important for youth from nondominant groups who frequently experience school science spaces as places where settled expectations of normative behaviors and epistemologies are in conflict with their lived experiences and interests (Bang, Warren, Rosebery & Medin, 2012) and also has the potential to disrupt powered relationships in classrooms (Warren & Rosebery, 2011). While inclusive epistemic agency plays an important role in learning, it does not present a way of thinking about youth participating with epistemic agency that allows youth as the members to define the context of inquiry or re-define forms of science participation. Truly redefining epistemic agency as a members' experience calls for an exploration of the ways that youth participants' agency *transforms* STEM spaces (Calabrese Barton, 2001; Calabrese Barton & Tan, 2010). Calabrese Barton (2001) explored this within the context of urban schools where young women redefined what "making progress" in STEM learning spaces could look like. In the OST program, redefining participation led the youth and scientists to collaboratively create new sampling, analysis, and data processing protocols in response to questions posed by youth participants and to transform communication. For example, the team co-created a new sampling kit using glass bottles because the youth wanted to be able to test for chemicals in plastics and the old sampling bottles would have contaminated the water. Youth and scientists collaboratively created a new inquiry pathway—they asked a new question requiring the development of new procedures and materials. The lab then adopted these procedures as part of their standard practice. Thus, youth *transformed* the practices of this lab as they became members of it. Drawing upon EAME aligned with a critical historical perspective sensitizes us to transformative outcomes.

Discussion and implications

We have presented a conceptualization of epistemic agency that centers our attention on the experiences of participants, especially the powered nature of interactions in which participants (learners and educators) negotiate

the contexts of inquiry. We introduced the frame of *inquiry as a members' phenomenon* to draw our attention to the ways in participants jointly negotiate the context of inquiry. We demonstrated how drawing on IMP orients our attention to the beginnings and endings of inquiry as key moments of negotiation where we can see learners' experiences of epistemic agency. We saw students' competence in articulating their confusion and deciding whether there was a problem to be investigated. We also saw students' competence in orienting both themselves, and then their teacher, to a satisfactory ending of inquiry by their own terms. We then drew upon that representation of *epistemic agency as a members' experience* at a different analytic scale and in conjunction with a critical historical perspective to orient us not only to learners' competence in negotiating beginnings and endings, but to position youth to transform ongoing disciplinary practices of STEM laboratories to include new practices that reflect new contexts of inquiry negotiated based on their own interests and concerns.

What does this mean for us as researchers and as educators? First, assuming that learners are capable of exerting epistemic agency is an important first step, and working to create pathways in which they *experience* that ownership and power is a critical design goal. Many of the existing examples in the literature are cases in which students' epistemic agency was emergent through a confluence of design factors (e.g., Engle & Conant, 2002); cases of environments explicitly designed to support students' epistemic agency are rare (see Calabrese Barton & Tan, 2010, Bang et al., 2017 as examples of spaces intentionally designed to support students' epistemic agency). In part this is because the goals of having learners participate in science practices in ways that position them to engage deeply with the substance of ideas and to take ownership in navigating the investigations that work to build them (Reiser, Novak, & McGill, 2017) are incredibly difficult to realize fully in classrooms. We are drawing upon carefully selected moments to push forward our conceptualizations of epistemic agency, and to remind us that "agency" is not only about providing choice, but that it requires careful decision-making about the nature of those choices. It requires thinking first about how participants would experience the constraints and affordances of those choices, and how that experience might shape future possibilities for decision-making and interaction.

We also see how when learners are positioned as competent, we should expect to be unsettled. Attending to issues of power and equity in learning requires that learners be positioned as epistemic agents with the power to transform the context of inquiry, both in regards to the practices and paths. This requires active work on the part of facilitators to support students' transformative work. It also requires support for educators to learn to navigate *with* students rather than *for* students. The examples presented here illustrate how teachers and facilitators had to "let go" of their plans and follow learners. In terms of teacher learning and PD, we need new heuristics and criteria that teachers/facilitators can learn to leverage in supporting students, both as competent epistemic agents, and as transformative epistemic agents who disrupt existing powered relations.

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