Developing Teachers' Pedagogical Design Capacity to Amplify Students' Epistemic Agency through Curriculum Adaptation

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Abstract: In this study, we analyze teachers' participation in a professional learning (PL) workshop that aims to deepen teachers' pedagogical design capacity, with an emphasis on increasing students' epistemic agency. We describe the design of a four-day workshop, our analytic process, and how three teachers made sense of and deepened their sensemaking of students' epistemic agency. Although the three teachers began with different conceptions of epistemic agency, each of them shifted their conceptions over the course of the workshop, toward a deeper reflection of how talk, tasks, and teacher moves support or hamper opportunities to let students co-construct ideas. We conclude with a discussion of the implications and future directions for our work.

Introduction

Transforming classroom learning inevitably involves contending with the messy and loosely coupled system of standards, curriculum, and schooling. In the U.S., reforms in science education over the last decade have been spurred by a vision of science learning where students are engaged in *doing* rather than memorizing science, and teachers solicit and build on students' ideas (NRC Framework, 2012). The Next Generation Science Standards (*NGSS*, NGSS Lead States, 2013) were generated a year later—a document that would guide the redesign of 3-dimensional learning objectives for science instruction that braid together disciplinary core ideas, science and engineering practices, and cross cutting concepts. Historically and currently, curriculum materials are seen as a key lever for bringing this vision and set of standards to life in transforming the tasks, questions, and practices that students engage in in the classroom. The proliferation of high-quality, open-source science curriculum materials aligned to the Framework vision and NGSS in the U.S. reflects a belief in the power of curriculum materials as a key lever for moving toward more equitable and meaningful science education.

Given the historical and ongoing investment in developing high-quality curricula, we must examine *if and how* teachers utilize curriculum materials as resources for transforming science learning for students. Decades of work in science and math education underscore the dynamic, complex, emergent and contested relationship between teachers, curriculum materials, and students (Brown & Edelson, 2003; Drake & Sherin, 2009; Ko & Krist, 2019; Remillard & Kim, 2020; Shulman, 1986). This body of work problematizes transmissionist models of enactment where teachers simply propagate materials exactly as they are written (Cohen & Ball, 1990). This model does not sufficiently acknowledge teachers' agency to adapt these materials to best address the needs of their students, in response to the sociopolitical contexts in which they teach (Superfine et al., 2022). A recent survey further emphasizes the importance of empowering and equipping teachers to leverage curriculum materials to support more meaningful and equitable science learning. Doan et al. (2023) found that less than 16% of the surveyed MS teachers (N = 409) and less than 27% of surveyed HS teachers (N = 459) are using district/school-recommended or required curriculum materials. Thus, while high-quality curriculum materials continue to be designed and disseminated, science teachers, by and large, design their own curriculum, even when curriculum materials are mandated or recommended by their building administrators or districts (Doan et al., 2023).

While curriculum designers may be discouraged by such findings, we see a novel opportunity to explore how we might support teachers in developing new lenses for designing curricula, while productively leveraging the features of high-quality curriculum materials. Here, we draw on the concept of *pedagogical design capacity* (*PDC*). Brown and colleagues (Brown, 2009; Brown & Edelson, 2003, Davis et al., 2011) describe PDC as the capacity to perceive, select, and mobilize curricular resources to craft instruction. Consonant with the survey findings above, PDC centers the design work that is inherent to the work of teaching and "calls attention to the constructive interplay…between agents, tools and curriculum materials and the manner in which the characteristics of each shape the outcome" (p. 23, Brown, 2009). Like Cohen & Ball (1990), we believe that "teachers do not simply assimilate new texts and curriculum guides, altering their practice in response to externally envisioned principles" (p. 335). Instead, teachers need to develop their principles and visions for science learning in ways that enable them to utilize curriculum materials in dynamic and adaptive ways.

Our study aims to build on this existing literature on PDC, with a focus on how to sharpen teachers' ability to see students as critical, agentic sensemakers who can take ownership of their own learning. The dominant models of the teacher-curriculum relationship (e.g. Remillard, 2005) background students' roles and experiences, yet transforming science learning requires redistributing the traditional power dynamics between teachers, students, and the curriculum. Moreover, while recently developed open-source curricula design for, measure, and respond to students' experiences of these materials (Edelson et al., 2021), we know little about how curriculum-linked professional learning can help shape teachers' attention to student agency and ownership. In this study, we ask: *how can professional learning support teachers in developing their pedagogical design capacity for attending to students' epistemic agency?*

Professional learning design

We take up this question in the context of a EMPOWER professional learning (PL) workshop focused on deepening teachers' understanding of *students' epistemic agency* and using it as a lens for curricular adaptation. We define epistemic agency as a feature of a group rather than an individual (Damşa et al., 2010) and something that is negotiated and emergent as students work toward a shared knowledge product. In the context of science classrooms, amplifying students' epistemic agency requires that they take the lead in deciding what knowledge is valuable and how to go about developing that knowledge (Miller et al., 2018; Stroupe, 2014). In the context of curriculum adaptation and enactment, attending to students' epistemic agency requires a careful analysis of the ways that the tasks (designed or adapted), participation structures, and teacher and student talk moves work together to amplify or reduce students' epistemic agency (Ko & Krist 2019).

We recruited teachers from a suburban Mountain West district in the United States to engage in a four-day (32-hour) PL workshop in the summer of 2024. Over the four days, we engaged teachers in activities designed to familiarize them with epistemic agency and explore its impact on curricular adaptation. On the morning of Day 1, we solicited teachers' initial ideas about epistemic agency. We built a concept map of teachers' initial ideas about epistemic agency, engaged in professional readings, and then revised these ideas and used metaphors to describe the role of teachers, students, and curriculum materials in supporting epistemic agency. In the afternoon, teachers selected and analyzed a curricular unit they intended to enact in the Fall (of 2024) to identify possible adaptations that could foster greater epistemic agency. On Day 2, teachers analyzed their units more deeply, going lesson by lesson, to identify what students were doing and what they were figuring out in each lesson. Some of these curricular units the teacher chose were open-source Storyline curriculum materials (e.g., Edelson et al., 2021; Reiser et al., 2021), while others were not.

On Day 3, teachers worked collaboratively to rank a series of 11 student indicators along a continuum in order of *greater* or *lesser* student epistemic agency (see Figure 1). They also ranked 11 teacher indicators as reflecting *greater or lesser teacher authority*. For example, the indicator *Teacher sets the intellectual agenda for the activity* might be reflective of greater teacher authority, while the indicator *Teacher deepens student-to-student discourse and moves student ideas to the center of disciplinary work* might be considered an example of lesser teacher authority. Students' epistemic agency relates inversely to teacher authority (e.g. great teacher authority correlates with lower epistemic agency).

Figure 1
The Final Product of the Continuum Sorting Task.
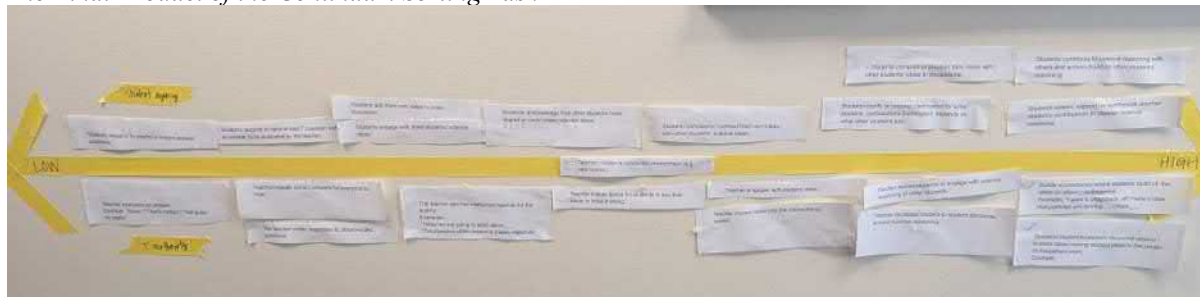
Teachers "Ranked" Each Indicator Based on Their Perceived Sense of Whether These Statements Reflected Greater/Lesser Student Agency and Teacher Authority. Student Moves Were Organized Above the Arrow, and the Teacher Moves Below It.

We printed these indicators on strips of paper and distributed them among the teachers; we told them there was no right or wrong way to organize them. Each teacher read the indicator out loud and then discussed where to place it on the continuum as a group. For example, one teacher read aloud an indicator that stated *students*

engage with other students' science ideas, and then remarked, "That's high [on the continuum], but probably not as high as [ones where students are] extending, expanding, or synthesizing". They did the same with the teacher indicators, often referencing the student indicators to make their determinations. This task drew from the *Authority and Agency Relations between Teacher and Students* (AARTS) coding scheme, which was developed and then applied to classroom talk in secondary math, science, and English language arts classrooms (Pitvorec et al., 2022).

After the continuum sorting activity, teachers watched two contrasting videos from a math teacher's classroom, 2 years apart, and took notes on differences in 1) teacher and student discourse and 2) the task design. For the remainder of Day 3, teachers returned to their focal units to identify possible adaptations that would amplify students' epistemic agency. On Day 4, we invited each teacher to draw on their evolving understanding of epistemic agency to develop their own research question. We worked together to develop an exit ticket template that teachers could modify (based on their own research questions) and administer over the course of the year to get insight into how students were viewing their own contributions to classroom discussions (see Penuel et al., 2023). We ended the day by discussing a preliminary plan for collecting data and plans for PL during the academic year.

Participants

Five teachers (three middle and two high school) from the same district in a western suburban U.S. district participated in the workshop, recruited through the district's science coordinator. The five teachers differed markedly in their experience with high-quality science curricula. On the one hand, one MS teacher had been using some version of Storyline curricular units for 10 years across districts and states. On the other hand, one HS teacher used a variety of materials throughout their tenure and came to the PL wanting to adapt a locally developed unit on air pollution. This variation in teachers' dispositions and curricular commitments is ideal in understanding how PL can support a wide range of teachers and their development of pedagogical design capacity with attention to students' experiences.

Data and analysis

The data for this study was collected over the four-day professional learning (PL) workshop. We collected video and audio recordings during the workshop and photographs of teacher journals and teachers' adaptation materials over the four days. The first two authors served as facilitators during the workshop, while the third author took detailed field notes documenting whole group conversations and transitions between activities. At the end of each day, the research team debriefed by sharing observations about teachers' participation in different activities, adapting our agenda based on these observations, and earmarking "juicy" video moments worthy of review and analysis. The video and audio recordings and transcripts we obtained were reduced and uploaded to MaxQDA software for initial analysis.

To investigate how the PL supported teachers with pedagogical design capacity for epistemic agency, we reduced the data corpus to video episodes where teachers' learning about epistemic agency was made visible through joint work or sensemaking talk. For example, we excluded unit-specific work time (48 hours of video) since teachers worked primarily alone or in dyads, limiting the amount of sensemaking talk they were doing. Specifically, we analyzed Day 1 episodes where teachers shared their initial ideas about students' epistemic agency and used metaphors to think about theirs and students' role in making that a reality in their classroom. We also analyzed the Day 3 episodes involving the continuum sorting and video analysis. During our debriefing discussions as a research team, we marked Day 3 as an inflection point where teachers moved from talking about curricular adaptation in general and sometimes pragmatic ways (e.g., what to cut, streamline, or swap out) to thinking substantively about the kinds of modification that could possibly shift agency (and power) over to students.

The transcripts and videos from these 7 episodes were reviewed in two rounds. First, we reviewed them holistically to understand how the teachers collectively engaged in the episode. Second, we conducted a teacher-focused analysis, tracing each teacher's participation across the episodes. These "across" and "within" analyses allowed us to understand what was unique to each teacher, leading to the development of cases (e.g., Stake, 2008) of possible paths for teacher engagement in each PL activity. We focused our analysis on the 3 teachers with the most experience with storyline curriculum materials to better understand how their sensemaking of epistemic agency shapes their sensemaking of curriculum materials. To avoid confusion, we *italicize* the teacher/student talk moves that were printed and sorted by the teachers (see Figure 1) in the Findings section below.

Findings

In our findings, we focus on how Ms. Gabriel, Ms. Childers, and Mr. Lewis engaged in activities designed to explore the idea of students' epistemic agency. For each teacher, we describe their initial ideas about students' epistemic agency and the metaphors they used to describe their roles in supporting it on Day 1. We then explore how these ideas expanded or shifted on Day 3, as they engaged in the continuum sorting and the video analysis activities.

Ms. Gabriel: Attention to contingency and collective sensemaking

Of all the workshop participants, Ms. Gabriel, a middle school science teacher, had the most extensive experience using storyline curricula (over 10 years). Her curricular knowledge and expertise was reflected in the metaphor that she chose to describe her role on Day 1. She described her role as the "GPS in a car," because she "knows where we are supposed to go on the storyline", while students are the engine powering the car and moving through the unit. She also noted that these roles were dynamic, shifting based on where they are in the curricular sequence:

> "And I feel like it sometimes changes…I think if there's, there's moments where…you do need to keep direct instruction…. And other times, there's a kid who's really capable of being that leader, and then sometimes that kid needs to step to the side and be the listener – the ones like receiving something from a classmate. So…that's changing frequently."

Of all the participating teachers, Gabriel was the only one who brought in the curriculum materials as part of her metaphor. She later commented that storyline curriculum materials involve "detours" from written materials. In her role as the GPS, she redirects students toward the curriculum's intended goals. In her metaphor, Gabriel highlights the dynamic way that the teacher and students take on different roles in the process of co-constructing ideas, and how the curriculum serves as a roadmap (and guard rails) for their journey.

On Day 3, Gabriel worked with other teachers to sort the teacher and student indicators along the continuum of teacher authority and student agency. When another teacher read the indicator *Students clarify or request clarification for other students' contributions. Contingent,* Gabriel recognized an area of growth for her instruction. The teachers first discussed that *contingent* describes turns of talk when one students' contribution *depends* on and *builds from* a previous student's turn of talk. Contingent conversations involve students listening and building on one another's ideas. Then, Gabriel shared that contingency was something she struggled with. She said:

> "...I also find that I…struggle with the contingency [piece]…we all have diverse classrooms…It's like over time, there's kids who cognitively know all the parts [of a model] and just want to get to the final part. And when we talk about, like, mechanisms to get there, like, what that looks like… if no one has kind of shared, well…that's really hard for middle school [students]..."

Here, Gabriel highlighted the challenge of engaging students in joint sensemaking, especially when some students "get it" but others do not. This remark is connected to her comments on Day 1 about the importance of taking on different roles. In puzzling over a possible next step for addressing this conundrum, Gabriel began to brainstorm how a curriculum tool could be re-purposed to scaffold students into "contingent" conversations. In her words:

> "…I feel that if you use the OpenSciEd discussion planning tool, like as a teacher, and you're planning a discussion, you're thinking about what *you* need to say in a discussion, but it's almost like we need to revamp it, to be like, what do you need to say, to *shift those questions from you to just students…you want the students to be asking the "well, how or why? What are we missing, or what's causing this?"* Versus you doing that? [the planning tool] gives you everything that you need and what to say…but how do we then shift that [to students]?"

Here, Gabriel suggested that a teacher-facing discussion planning tool could be revamped so that *students* can be scaffolded into leading and engaging with one another's ideas. Compared to her initial metaphor and conceptions of epistemic agency on Day 1, we see Gabriel consistently attending to teacher-student and student-student dynamics in thinking about epistemic agency, but with increasing attention to how she can turn the work over to students. She not only shared her struggles with facilitating linked or contingent talk but also proposed an adapted use of the discussion planning tool as a way to shift the intellectual work and ownership from her over to students.

Ms. Childers: Seeing how task design shape student talk

Ms. Childers, a high school Biology teacher, was familiar with the storyline approach and had used it as a framework for co-designing a unit in years prior. Childers has also helped create assessments for storyline units. On Day 1, Childers' view of students' epistemic agency was focused on relevance. In her journal, Childers wrote that epistemic agency is evident when "Students...are empowered in science class know what they're learning and WHY every day. They participate in asking questions to guide the direction of their learning and they trust the teacher/other students to collaboratively develop an understanding of something they care about". When it came to her role in supporting this kind of learning, Childers used the metaphor of a professional organizer who "curates student thinking (and supports students in curating their own thinking) to allow a logical progression of sensemaking".

On Day 3, Childers engaged actively in both the continuum sorting activity and the video analysis. During the activity, she drew the group's attention to the verbs in each indicator to determine the degree of teacher authority and student agency reflected therein. For example, Childers held up her strip of paper, which read *students engage with other students' science ideas*. To this she said, "I feel like that's high, but probably not as high as *extending, expanding or synthesizing*." Here and throughout the next 10 minutes of talk, Childers invited other teachers to discuss what the verbs *comparing, contrasting, engaging, reasoning* suggested about students' epistemic agency. Like Gabriel, the continuum activity also prompted Childers to reflect on how her students engage with one another in discussion. After a colleague read the strip of paper that said *students clarify or request clarification for other students' contributions*, Childers remarked, "I *never* gotten students to do that effectively". Her reflection here suggests that fostering student-to-student interaction in the classroom is an area for growth for Childers, highlighting an awareness of missed opportunities for student agency and peer interaction in her classroom.

Childers also attended to the ways in which task design and classroom culture open up opportunities for epistemic agency. This was evident in what she noticed and responded to during the video analysis activity on Day 3. After viewing the second video, one teacher pointed out that a student admitted that he was wrong and changed his mind in front of the class. In response, Childers commented, "even the first kid was like "oh, I think I made a *mistake*, because…". That is such an amazing word!" In addition to noticing the evidence of the class's culture for safety in risk-taking, Childers also noted how the teachers' instructional decision-making opened up or foreclosed opportunities for co-constructing knowledge in the video. Childers said,

> "There's also that intentional choice of which example to start with. If you start with an example that's really solid, there's not as much as, "let's change our thinking!" But the student who was asked to share initially *did not* have an entirely correct representation. So, there was something to play with".

Here, we see Childers noting the importance of selecting messy, "imperfect answers" as a way to encourage students' joint sensemaking. This was contrasted with the first video, in which the same teacher invited a student to share their strategy and then funneled them toward consensus on the correct answer. In comparing Childers' verbal contributions on Days 1 and 3, we see her move from articulating her role (as curator) to noticing how task design and instructional decision-making shape students' experiences and engagement. In thinking about the focal unit she planned to adapt, Childers hoped to re-design the anchoring phenomenon to be more locally relevant and engaging for the students, so that it was rich enough to invite more connection and contribution from students.

Mr. Lewis: Attention to talk moves as a means of redistributing power

Mr. Lewis had been using storyline curriculum materials with Gabriel for 4 years as a teacher in the same school. On Day 1 of the PL workshop, Lewis described the work of a teacher who supports students' epistemic agency as that of a stage manager, emphasizing the importance of spotlighting students' ideas and inviting students to contribute to classroom learning:

> "My metaphor was a stage manager…to make sure that the props are in the right spotlight, and nobody misses their cue…[I would] look over someone's shoulder and say "can you share what you wrote in your notebook?" …so prompting, nudging students to participate."

Later, in the same whole group discussion, Lewis elaborated on what he chooses to spotlight, saying, "Sometimes you highlight particular students and other times, a pattern or data ... we have to highlight ideas that we know are going to be useful because we have a bigger sense than what students have." He also needed to decide "when the curtain comes down…. [because] I need to get here by break!" As a stage manager, Lewis attends to cues and

creates a production plan for supporting students' epistemic agency. This involved an understanding of how a specific students' ideas in light of the goal and arc of the storyline, constrained by the limited time he has to cover the unit.

During the continuum sorting activity on Day 3, Lewis asked questions, provided elaboration, and built on other teachers' ideas. A recurring theme in Lewis' contribution during this conversation was a sharpened focus on the distribution of power between teachers and students, and what the various teacher and student indicators implied about who holds the power in the classroom. For instance, in response to the indicator *teacher moves students' ideas into the interactional space*, Lewis noted that "it's a power move, because it's like, there might have been 15 things said in the discussion before that, and now you're singling out one, to say, like, "Hey class…this is an important enough we need to talk about more". Note that this example resonates with the way that he described himself as a stage manager on Day 1; however, in the context of the continuum activity on Day 3, Lewis elaborated on the ways that the teacher/student moves signify power relations in the classroom. Later, when discussing whether and how teachers create a conducive environment for sensemaking, Lewis pointed out that teachers can exercise power without taking away opportunities for students to co-develop ideas. In his words, making space involves:

> "…almost a relinquishing of power. I mean, like, you're *using your power* to create safety…to say, 'hey, we're not going to jump down somebody's throat if they say something we disagree with,' but you're then *giving power* to students to then speak up and share."

Compared to his initial metaphor and conceptions of epistemic agency on Day 1, we see Lewis' talk on Day 3 shift from a focus on his role (e.g. what students to call on, what ideas to select and privilege) to how his facilitation moves can redistribute power dynamics in the classroom. Later in the discussion, Lewis also noted how the curriculum materials could open up (or constrain) opportunities for increasing students' epistemic agency. He noted that discussion routines embedded throughout a given lesson tended to be written as "teacher-driven" instructions, because the examples that are provided in the teacher guides focused on moving students toward pre-specified scientific ideas. Like Gabriel, he agreed that students need further scaffolding to truly take the lead in co-constructing knowledge, and that providing specific prompts may encourage them to do so.

Discussion

In this study, we explored how teachers made sense of students' epistemic agency in a PL workshop that aimed to support the development of teachers' PDC. Gabriel, Childers, and Lewis' ideas about epistemic agency shifted in different ways, but always in connection to their perceptions and possible adaptations of curriculum materials. Although they had different conceptions of epistemic agency at the start, we saw Gabriel and Childers start to explore how instructional decisions, task design and discursive scaffolds might be used to amplify students' epistemic agency. Lewis, for his part, began to sharpen his focus on how talk moves can work to shift sensemaking power to students. For all three teachers, these realizations came through during the continuum sensemaking activity, which prompted more substantial reflection (from all teachers) on the challenges and tensions that were inherent to curriculum enactment. Moreover, this was the first time in the workshop where the teachers openly (and vulnerably) acknowledged that their current "reading" of the (written) curriculum materials was through a teacher lens—with attention to what they would select, prompt, or solicit from students, rather than thinking about how to transfer that power to students. From our view, the PL's focus on epistemic agency allowed teachers to wrestle with a key aspect of the reform vision for science education—what it looks and sounds like to reposition students as the knowers and doers of science, and use that as a lens for leveraging, adapting, and re-purposing curriculum materials to achieve that vision. These findings are consonant with other fields of human-centered design (e.g., Norman, 2013) that promote *experience* of the materials as a place to focus our thinking about design, and these results suggest that student experience-centered professional learning can support teachers in implementing ambitious, high-quality curricula.

Conclusion and implications

The EMPOWER PL workshop was designed "from theory to practice" to promote a vision-centered view of how to teach with students' epistemic agency at the center. We co-constructed a conceptual definition of epistemic agency on the first day and built a common vocabulary for what it looks like and sounds like for students to "own" their science learning. Then, we moved on to examine epistemic agency at the unit and lesson level (Days 1 & 2), and then at the micro-interactional level on Day 3 through the continuum sorting and video analysis activities. We took this approach as a way to anchor the teacher's noticings about use of the curricula in a common vision of

how students could be leading the intellectual work in the classroom, doing the figuring out and sensemaking with one another, rather than always being led by the teacher.

In a time of a proliferation of open-source, high quality instructional materials and related professional learning, this study explored a PL design/ model that pushed teachers to go beyond what they do to thinking about ways to redistribute power and authority in the classroom. While this work is preliminary, we are eager to explore how we might build on this initial work with teachers as they engage in daily adaptations inside their classrooms. We do not think that students' epistemic agency is the only starting point for these types of conversations; there are several "big ideas" that could help anchor curriculum-linked PL, rather than a focus on understanding the curriculum and its contents. This work has implications for designers of learning experiences, especially for professional learning and preservice teacher education, particularly for those who desire to center students' experiences and agency in disciplinary learning. This study also offers a possible teacher learning model that does not require that teachers commit to a wholesale, all-or-nothing use of a specific type or brand of curriculum materials. PL workshops that aim to build teacher's own conceptual foundations and critical lenses for examining and leveraging curriculum materials can support teachers' adaptive expertise, helping them a lens for noticing the kinds of curricular resources and students' ideas that can move students toward more agentive and meaningful learning.

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