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Preservice Teachers' Support for Children's Epistemic Agency in Elementary Science

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Abstract: Supporting children to make, explain, and reason through decisions about how to investigate scientific phenomena allows them to make sense of science content and practices in meaningful ways, positions children as agentic, and enables more equitable and just teaching. Novice teachers may use certain strategies and face unique challenges when engaging in this work. Drawing on written lesson plans, videorecords of lesson enactments, and interviews, this study explores five preservice teachers' ideas and practices that positioned children as epistemic agents and identifies common tensions they negotiated. Each teacher demonstrated beliefs in children's brilliance that were related to their practices, such as re-centering children's ideas, working toward collective understanding, and engaging children in science practices. This study highlights early strengths of these five teachers and raises questions about teacher learning.

Positioning children as epistemic agents

Rethinking who gets to do science is a central issue in the pursuit of equity and justice within both education and science (NASEM, 2022; Subramaniam, 2009; Tate, 2001). In destabilizing heteronormative Euro-centric ideas around who has the authority to engage in 'real' science, a new space is created where different questions, grounded in multiple onto-epistemologies, take on life (Kimmerer, 2013; Medin & Bang, 2014). If learning happens when people are "productive participants" (Damşa et al., 2010) in knowledge creation and have the authority to engage in science practices, how do preservice elementary teachers support children to be knowledge-generators and doers of science in ways that support their sensemaking? Meaningful science learning is possible when children co-construct knowledge together, requiring a deliberate attention to power dynamics between teachers and students and recognition of children's inherent strengths and agency (Esmonde & Booker, 2017; Ko & Krist, 2019; Rosebery et al., 2016). Supporting children's epistemic agency by working to 'hear' children can begin to disrupt epistemic injustices (Stroupe, 2022). Positioning children as epistemic agents is nonetheless challenging—particularly for novice teachers—and requires a deep respect for children as knowledgeable with cultures, experiences, and orientations that are central to learning (Calabrese Barton & Tan, 2010; González-Howard & McNeill, 2020).

The larger study in which this one is situated seeks to identify preservice teachers' beliefs and related practices as they plan for and enact lessons that support expansive sensemaking. Expansive sensemaking builds upon the idea of sensemaking as an iterative process where knowledge is co-constructed to figure out "how and why the world works" (Schwarz et al., 2021, p. 113) to incorporate multiple ways of knowing and doing science and consideration for who does science (Carlone et al., 2021; Nasir et al., 2022). Building on this literature, our conceptual framework emphasizes four interconnected themes and their associated strategies and beliefs: believing in children's brilliance, building a collaborative class culture, expanding what counts as science, and positioning children as epistemic agents. Here, we address two research questions focused on one of these themes: (1) What are preservice teachers' ideas about positioning children as epistemic agents? and (2) What moves do preservice teachers plan for and enact that promote this positioning?

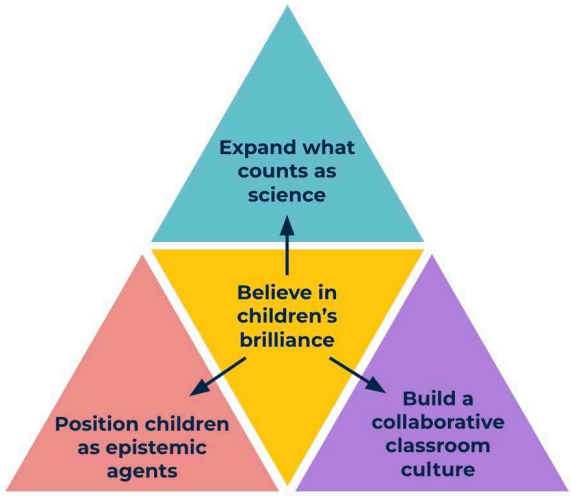
Conceptual framework

We developed a conceptual framework for expansive sensemaking that reflects the interconnected nature of the four themes identified above, as shown in Figure 1. Based on the literature and findings of this study, these themes interact with, build upon, and inform each other. A central tenet of this framework is that believing in children's brilliance is foundational to promoting expansive sensemaking (Moll & Greenberg, 1990; NASEM, 2022; Rosebery et al., 2010). For example, facilitating collaborative discourse, recognizing many forms of competence, and having children ask their own investigation questions are all supported by asset-orientations towards children.

This paper focuses on the theme of positioning children as epistemic agents, a key component of expansive sensemaking and one that is too frequently denied to children from marginalized backgrounds, particularly girls and children of color. When children's inherent epistemic agency is recognized and uplifted, they see themselves as knowledgeable, actively participate in the co-construction of meaning, and have influence

over classroom structures and lesson direction (Stroupe, 2022). Positioning children as epistemic agents requires flexibility and an ability and willingness to navigate pedagogical uncertainty (Ko & Krist, 2019). This can be challenging even for expert teachers and may require particular kinds of support for novice teachers. Recent studies have emphasized the ways teachers modify lessons, activities, and discourse practices based on children's ideas, particularly those that diverge from canonical narratives (Carlone et al., 2021; Schwarz et al., 2021).

Figure 1
Conceptual Framework for Expansive Sensemaking



We focus here on how preservice teachers positioned children as epistemic agents. These teachers' practices and beliefs should not be taken as a script for supporting expansive sensemaking, but rather as images of the possible and considerations for how preservice teachers might conceptualize and engage in this work.

Methods

The 25 preservice teachers in this study were part of an intensive four-semester integrated master's and teacher certification program at a large public university in the US. They were students in an elementary science methods course where they were asked to analyze and adapt an existing science lesson before teaching it in their placement classroom. They annotated their lesson using tools designed to support their use of science practices and equity and justice moves. Amber, Junto, Monica, Ruth, and Xavier (pseudonyms) were focal participants (see Table 1).

Table 1
Overview of Participants and Ccontexts

	Amber	Junto	Monica	Ruth	Xavier
Grade level	Grade 5	Grade 1	Grade 4	Grade 2	Grade 5
Lesson topic	Sea level rise	Day & night	Force & motion	Classifying matter	Sea level rise
Self-ascribed identities	White woman	Japanese man	Chinese American woman	White woman	White man

We coded and analyzed lesson plans from each teacher (n=25) in the science methods course and additional data for the five focal teachers, including video-recorded enactments and one semi-structured interview. While we developed initial codes based on the conceptual framework, we used an emergent process to modify these codes and develop subcodes (Saldaña, 2016). We used an iterative data analysis and memo-writing process that led to shifts in codes and the conceptual framework over time (Bryant & Charmaz, 2012). For example, we initially distinguished between epistemic authority and epistemic agency, ultimately deciding to present a unified concept of epistemic agency, as subcodes were highly interconnected in the data (González-Howard & McNeill, 2020). Table 2 shows initial codes and emergent subcodes reflecting both concepts. Preservice teachers who positioned children as epistemic agents supported children's scientific decision-making, allowed their ideas to drive discussions or influence the lesson, and/or supported exploration for children to figure things out themselves.

Table 2
Initial and Revised Coding Schemes Related to Centering Children's Authority and Agency

Initial codes and subcodes	**Promoting epistemic authority**	**Positioning children as epistemic agents**
	Public display of children's ideas	Supporting children to…
	Teacher revoices children's ideas	Decide how to organize or record data
	Children revoice other's ideas	Decide what data to collect
	Listening to understand	Design models
	Orienting children to each other	Develop investigation questions
	Probing for explanation & argument	Drive discussions
		Engage in open-ended exploration
Consolidated coding scheme	**Positioning children as epistemic agents**	
	Engage children in science practices	
	Publicly display and (re)center children's ideas	
	Orient children to each other's ideas	

We took an explicitly asset-oriented approach to thinking about the work of these teachers, emphasizing the value in seeing the strengths of their practice. We also recognize that teaching is complex, dynamic, and personal. In pairing teachers' beliefs with their practices, we are not claiming causal relationships, but rather acknowledging that beliefs and ways of being are entangled and reciprocal (Warren et al., 2020). Our presentation of these as connected is intended to clarify our arguments without artificially separating beliefs and practices.

Major findings

We developed three assertions to address our questions around teachers' beliefs and practices: (1) Teachers demonstrated that children's thinking and funds of knowledge have inherent value by publicly displaying and (re)centering children's ideas; (2) Teachers believed that learning is social and used questions to orient children to each other's ideas and ensure collective understanding; and (3) Teachers believed that children are capable scientists, engaged children in science practices, and saw science practices in their play. In the sections that follow, we unpack each assertion, providing evidence and illustrating tensions that arose for the participants.

Assertion 1: Teachers demonstrated that children's thinking and funds of knowledge have inherent value by publicly displaying and (re)centering children's ideas.

All focal teachers publicly displayed or (re)centered children's ideas in some way during their recorded enactment. While these types of moves are expectations of the teacher preparation program, and in some ways fall under the category of 'just good teaching,' teachers approached these strategies in ways that worked to identify children as authoritative knowledge holders and position children as epistemic agents (Ladson-Billings, 1995).

Junto, for example, wrote in his lesson plan, "Show what the student is talking about to the class using the manipulatives to ensure that all students can also visually see what is being talked about." This kind of public display is distinct from making a list of children's ideas on the board as he considered how to support shared understanding among a class of first graders. In planning to take time to use manipulatives to aid children in explanations of their thinking, he underscored his belief that children have valuable things to contribute while creating implicit opportunities for knowledge-sharers to confirm that their ideas were taken up accurately.

Ruth noted and addressed this concern of ensuring that children's ideas were represented correctly in her lesson plan, writing, "Avoid changing student contributions to the discussion such as with paraphrasing or word substitution, honor what students say as they say it." Her intention to "honor" children's ideas and experiences as inherently meaningful included attending to how she would (or would not) mediate their ideas as an authority figure. Later in her lesson plan, Ruth indicated that she would photograph how children organized their data and include these images as a support for later sensemaking. While it was unclear if she took these photographs during her enactment, her plans highlighted how she thought about publicly displaying and (re)centering children's thinking, emphasizing children's ideas as inherently valuable and supportive of collective learning.

Amber repeatedly brought children's ideas back to the center of discussion during her enactment. While children were working in small groups, one child suggested to Amber a new method for collecting and representing their group's data. Amber took up this child's idea and later presented it to the whole class, saying, "I saw a couple different ways of calculating [the data], and I was talking to [this child] about it and we figured out that if we're going to graph our data that this way might make the most sense." This unplanned moment emphasized Amber's belief that children's ideas have value and, by making substantive changes to the data representation procedures, centered this particular child's epistemic agency. In doing so, she also laid a foundation

for others to assert their own agency by demonstrating her commitment to uplifting their thinking. Table 3 provides additional examples of evidence supporting Assertion 1.

Table 3
Additional Evidence Supporting Assertion 1

Additional evidence from multiple data sources
Record student thinking on board or chart paper whenever possible (or makes sense) → shows that student thinking is valued in this space (Amber, lesson plan)
Are you all happy with the list here?... Does everyone agree with that? (Junto, enactment)
Have each group graph their results on the back and front whiteboards. Once a group is done, they can walk around and see what data other groups got. (Xavier, lesson plan)

There were also examples of tensions that teachers negotiated, particularly around sometimes competing desires to uplift children's ideas and make progress towards learning goals. During her lesson on sea level rise, for example, Amber elicited children's ideas around how to design their models and illustrated one child's idea on the board. Later in the lesson, however, she erased these drawings and replaced them with an illustration that reflected the version in the lesson plan. As she drew the updated model, she explained her thinking to the class:

> I'll draw my idea and see what you guys think. It's similar to [a child's] but we're going to have to fill the tub with water to represent the sea, so we need to make sure there's some land outside of the water. So instead of just one really flat layer it might be more of like a mound, like this, and then our ice cubes could go here and then our sea level would be here.

This sequence seemed like an attempt to support children's epistemic agency that was then mediated by her own uncertainty around how their model designs might change the outcomes of the lesson. This is not an uncommon tension, especially with novice teachers, and is one where additional classroom observations would help to understand how Amber approached similar moments, especially after gaining more science teaching experience.

Assertion 2: Teachers believed that learning is social and used questions to orient children to each other's ideas and ensure collective understanding.

Teachers also viewed learning as social, demonstrating this in how they used questions to orient children to each other's ideas and support collective understanding, both among children and between child and teacher. This intention to understand, especially when connections were not readily clear, highlights the value teachers placed in children's thinking and in the social nature of learning.

Junto was the only focal teacher to orient children to each other's ideas by having them explain another child's thinking. When eliciting children's ideas during his enactment in a first-grade classroom, Junto said, "We're going to try to write that on the board. Who can explain what [this child] just said?" This move recognized children's ideas as valuable enough for others to repeat while drawing on Junto's belief in learning as social in that he supported children to both share ideas and made sure they were understood by others.

Amber shared in her interview how she used questioning strategies to orient children to each other's ideas, saying, "'Oh, did you notice the same thing that this person is noticing?' Or like, 'Oh, I see you wrote that, but this person in your group didn't write that. Like, what are you thinking?'" She also described how she worked to make sure she understood children, and how important this was to her:

> I really try to listen to what kids are saying before responding. Just kind of as a baseline goal, I need to hear what you're saying before I try to make sense of what you're saying. And so like, whether that be—well you know, listening through an entire thing a kid is saying—but also asking follow up questions like, 'Oh, what did you mean by that?'

In both examples Amber described using questions that centered curiosity about children's thinking and modeled this curiosity for others in the class. Her intention to make sure children were understood by herself and each other emphasized how their learning is co-constructed while asserting children as knowledgeable thought partners.

Monica used a similar strategy, noting in her interview how she supported children to engage with each other: "I would go around and say like, 'Okay, so who's the expert on this? Why don't we ask them a question? What question do you want to ask them?' And I try really hard not to speak for them." Here Monica specifically planned for children to take on an 'expert' role during the lesson and reiterated that these children were the

knowledgeable authority figures on their topics. While this exchange took place during a social studies lesson (Monica was the only focal teacher who did not lead a science lesson in her second semester of student teaching), it illustrates how she thought about positioning children with epistemic agency. She also emphasized this strategy as an important yet challenging part of her own practice.

Ruth reflected in her interview on how her approach to understanding children's thinking shifted after her experiences in her science methods course and student teaching:

> When I'm listening to the ideas that come up, sometimes initially I'm like, how is that related to what we're talking about? But I'll just ask way more clarifying questions than I think I would have prior to these experiences [in student teaching]. I think maybe prior I would have been like, 'Well thanks for being brave and sharing, can someone help us out?' But now I'll just ask questions to see if I can find out where the link is between what I said or what was presented, or what someone else said, and what, you know, the student's thinking is.

This example provides insight into the ongoing evolution of Ruth's beliefs and practices in ways that increasingly demonstrate value in children's ideas and emphasize collective understanding as central to her teaching practice. Table 4 provides additional examples of evidence supporting Assertion 2.

Table 4
Additional Evidence Supporting Assertion 2

Additional evidence from multiple data sources
I saw some other groups who saw that too. Did everybody hear what [this child] just said? [Child's name] can you say that again for everybody? (Amber, enactment)
They're not sharing in a prosocial way, like raising their hands. They're yelling in front of everyone. But that's still like, a step, you know? (Junto, interview)
'What do you notice about what they are doing? What do they notice about what you're doing?' Because I was hoping that in doing that, it would kind of give a more equitable platform for students to get ideas and bounce off each other. (Ruth, interview)

While teachers' intentions to have children learn from and with each other was often prevalent in their interviews, some focal teachers, like Amber, noted a concern over the possibility of children getting "stuck on the wrong idea." This tension between supporting children to engage with many ideas and wanting to avoid "spreading misinformation" was evident in both the case of Amber and Xavier. Amber explicitly described how she thought about this as a challenge for her practice, saying in her interview,

> I want to give kids space for kids to explore their ideas, and their thoughts, and be able to parse that out. But I also don't want them spreading misinformation to the class, and like having to work backwards to try to correct that. And I think that was something that was always in the back of my mind, especially as someone who does not have a very strong science background. This was—like I had to do research to teach this. And so it's like, I don't necessarily feel super confident in my ability to convince you that what you're saying is wrong.

While she worked to negotiate this concern around controlling the way "misinformation" was addressed, Amber continued to engage in layered moves that worked in concert to promote children's epistemic agency. In her lesson planning, enactment, and interview, Amber prioritized children's knowledge, experiences, and ideas as being central to their own and each other's learning, decentering her own authority, and, in doing so, emphasizing the value in collective understanding and disrupting dominant norms of scientific engagement.

We also identified this tension within Xavier's case, though he was less explicit. As he reflected on his student teaching experience, Xavier described having children "think through ideas" in small groups, adding a caveat: "I normally try not to have any serious sensemaking happen in these small groups. I want that to be something where I can, kind of, that's whole group where there can be whole group instruction." In this example, Xavier seems to be prioritizing teacher-led whole group discussions as central to sensemaking, rather than small groups where he may not have access to guide, support, or mediate each conversation. This does not take away from his emphasis on learning as social—he still recognized collective engagement as central to sensemaking—but it does seem to suggest that he believed *he* should be mediating children's co-construction of knowledge.

Assertion 3: Teachers believed that children are capable scientists, engaged children in science practices, and recognized science practices in their play.

Each focal teacher emphasized a belief that children are capable scientists. The way teachers engaged children in science practices and saw these practices in children's play demonstrated the clearest connections to this belief.

During Monica's enactment, children explored potential and kinetic energy using pendulums. She directed children to hold the bob of the pendulum at 'half height' and at 'full height' before releasing them. While facilitating children's small group investigations, Monica noticed that groups were interpreting 'half' and 'full' height to mean different things. Rather than clarifying her own or the lesson's definition of these two positions (and thus 'correcting' children), she let children continue with their data collection using their own definitions and engaged them in discussion around this difference later. She described what she observed in the class's collective data and asked children to reflect on it: "I noticed some of these were on a totally different scale—9 and 19, 8 and 19—what are some things you may have done differently from group to group?" One child commented on the height of the bob, which Monica then elaborated on. Monica's move to first allow children to make decisions about data collection and then facilitate a dialogue around these processes afterward highlights her intention to position children as 'doers' of science by meaningfully and explicitly having them engage in science practices, in all their messiness. This was further reinforced in her lesson plan and interview where she explained that children being able to see themselves as scientists was a central focus of her practice.

Junto made his view of children as scientists clear in how he interpreted their play, especially when he described an interaction he had with one first-grader who had taken to making 'potions':

> My mentor teacher would redirect the student, but the student is doing some science there, you know? And I've engaged with the student, and I'm like, 'What are you making?' And the student's like, 'I'm making a—like a love potion.' I'm like, 'What's in the love potion?' And the student was like, 'You get marker. You draw—like your wish—on a piece of paper, and you put it in the water. And then the ink will bleach.' I'm like, 'What's in the cup?' And the student was like, 'It's water and hand sanitizer.' Like, 'Why'd you put hand sanitizer in it?' And she was like, 'I've tried so many things and hand sanitizer was the only thing that works.' But the student there was doing some science, you know?

This example reflects many of Junto's beliefs and practices—how he centered curiosity, sought to understand children deeply, and often assumed there may be more to children's play than at first appeared. It also underscores his commitment to helping children make connections between their own experiences and science practices. Though we only have Junto's perspective of this interaction, his perception of this child's play as an aspect of their scientific understanding may have supported him to make other connections between children's experiences and what it means to 'do' science. Table 5 provides additional examples of evidence supporting Assertion 3.

Table 5
Additional Evidence Supporting Assertion 3

Additional evidence from multiple data sources
'What type of data should we collect or what types of observations should we make to help us answer our investigation question?' (Amber, lesson plan)
I think getting them through the experiment and talking to them like a scientist, not using easy words—like actual scientific terms—and they'll feel empowered that they can actually do it. And they're like scientists. (Junto, interview)
There are a few things we COULD measure and collect here (science doesn't have just ONE right answer, ONE right procedure) - instead asking, what is relevant and helpful here? (Monica, lesson plan)

A major tension related to teachers' belief that children are capable of meaningful engagement in science practices centered around ideas about agency. There were times when teachers planned to support children's agency in ways that were not necessarily epistemic or related to their scientific decision-making. Xavier, for example, planned to have children "think collectively on how they want to make their two models in their table groups," but during his enactment told children to add their own "creative touches," focusing on aesthetic rather than epistemic decisions. He gave them time to brainstorm designs for their models, but included specific requirements that restricted these designs to stay within the lesson's boundaries. It is possible that Xavier may not have distinguished between an aesthetic and epistemic agency, especially as his lesson plans seem to intentionally refrain from being overly-prescriptive of children's constructions.

Discussion

We introduced this work with questions around beginning teachers' ideas and practices that support expansive sensemaking, specifically in how they position children as epistemic agents. The focal teachers in this study made principled adaptations of curriculum materials with justice and equity goals in mind, including explicit considerations for how and when they might open-up curricula for children to engage meaningfully in scientific practices and act as decision-makers (Ko & Krist, 2019). In doing this work, tensions around navigating their own uncertainties stood out as particularly salient, especially as some of these teachers seemed to embrace and reflect on these tensions (Hammer, 1997). Related to this is also the question of how teachers conceptualized agency and, perhaps more broadly, children's ownership over their learning. For example, it is possible that teachers like Xavier viewed creative decision making as epistemic in nature; they may not have had other understandings of agency in that moment. How novice teachers conceptualize and reflect on children's agency, and how they are supported in this work, may influence how they adapt curricula to promote epistemic agency.

Connected to teachers' concerns about progressing towards curriculum or standards-aligned learning goals were fears around children learning the 'wrong' thing. Of the focal teachers, Amber and Xavier were the most uncertain about their own science content knowledge. They grappled with this during their interview and/or in their science methods reflection journals, which were used as secondary data sources. As Ko and Krist (2019) note, "Navigating the landscape of possible trajectories requires a deep familiarity with curriculum and trajectory and how each investigation advances students toward the target explanatory account" (p. 996). Monica and Junto, who indicated a comfort with and confidence in science, may have been more well-positioned to make in-the-moment decisions that further opened up curricula, supporting children as scientific decision makers.

Implications, areas for further research, and conclusion

One implication for this work is in thinking about how novice teachers navigate uncertainty in their own practice as they seek to position children with epistemic power. Understanding how teachers approach these ideas and actively plan for and enact practices that position children as epistemic agents is pivotal in the work to provide more just learning experiences for children, particularly those from marginalized groups (Esmonde & Booker, 2017). The examples shared here give insight into what potential points on a trajectory of elementary science teacher learning and practice might look like. In exploring the tensions teachers negotiated, new questions arose around how teachers' beliefs and practices might shift over time as they enter their first years of teaching, each with unique classroom, school, and community contexts (Davis et al., 2020). An extension of this work might consider how can teacher preparation programs support novice teachers to critically reflect on their own uncertainty and the role it plays in their curricular adaptations and enactments, particularly those in elementary who are not science specialists (Ko & Krist, 2019; Manz & Suárez, 2018).

A limitation and important area for future research is in attending to children's own perceptions of their epistemic agency. Did children believe they were 'doing' science? Did they perceive themselves or others to be knowledgeable authority figures in the classroom? Were there moments when children felt they made meaningful contributions and decisions that supported their own and collective learning? Some of these areas, and other implications for children's engagement, could be explored by asking teachers to share their own interpretations of engagement. Involving children in these conversations, however, would be pivotal in demonstrating how we, as researchers, also believe in children's brilliance and recognize their ideas and thinking as inherently valuable.

Beginning teachers are up against myriad challenges as they work to support children's expansive sensemaking. In this study, we have provided a glimpse at what early versions of this work might look like, with a focus specifically on positioning children as epistemic agents. We have done so in hopes of informing theory around central elements of teachers' development, as well as informing practice in teacher education such that teacher educators are better positioned to support these aspects of teachers' learning.

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