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Expanding Preservice Teachers' Conceptions of Science Teaching and Learning

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Abstract: To support students' sense of belonging in science classrooms, K-12 teachers should recognize and appreciate learners' diverse experiential, cultural, and linguistic repertoires as valuable resources for sensemaking in science. This approach to teaching necessarily entails expanding what has been traditionally considered as ontologically and epistemologically valid and valued in disciplinary learning spaces so that students' diverse ways of thinking, talking, and feeling are honored and built upon, rather than dismissed. This study explores the emergence of such expansiveness in the context of STEM preservice teacher education. Using preservice teachers (PSTs)' written reflections and in-class discussions, we identified different ways in which such expansiveness manifested in PSTs' discourse. We end with some implications for supporting teachers' expanding conceptions of science teaching and learning.

Introduction

Learners have varied and rich life experiences, cultural practices, and linguistic repertoires that serve as valuable resources for their sensemaking in science (Rosebery et al., 2010). In the United States, however, these resources often do not align with the Western disciplinary practices and discourses that are privileged and romanticized in traditional instructional goals (Bang et al., 2012). Such instructional goals are informed by a "selectively appropriated… unnecessarily narrow" framing of science that depicts the discipline as culturally neutral, value-free, and objective (Bang et al., 2012, p. 314). These zero-point epistemologies shape what is ontologically and epistemologically acceptable in science classrooms, often devaluing learners' own experiences and ways of knowing (Warren et al., 2001). This is especially true for learners from marginalized cultural, linguistic, and racial groups, as this narrow framing (re)produces deficit narratives about such students (Nasir et al., 2006; Rosebery et al., 2010).

It is crucial, then, to *expand* teachers' conceptions of science teaching and learning in ways that push the traditional boundaries of "what counts" as intellectually generative for scientific sensemaking and "who counts" as capable of meaningful engagement in science (Rosebery et al., 2016). Such expansive considerations necessarily entail orienting to all students as sensible and brilliant (Robertson & Atkins-Elliot, 2017), recognizing students' diverse ways of knowing and being—their onto-epistemic heterogeneity—as valuable for their science learning (Kayumova & Dou, 2022), and understanding the sociopolitical realities of schooling (Madkins & McKinney de Royston, 2019). Here, we examine how preservice science teachers' (PSTs) begin to develop such *expansive conceptions of science teaching and learning* in an early teacher education course. Toward this end, our exploration in this work is guided by the following: *(1) what are the ways in which PSTs developed more expansive conceptions about science learning? and (2) how do these expansive perspectives influence PSTs' evolving ideas about science teaching?*

Conceptual framework: Expansiveness

By expansiveness, we refer to teachers' broadened conceptions of science teaching and learning along three components: having asset-based orientations to learners, recognizing the value of onto-epistemic heterogeneity, and developing political clarity.

In traditional framings of science teaching and learning, students' own sensemaking resources are often ignored or viewed as deficient, which negatively impacts students' investment in their own learning and the opportunities they have to use these resources (Kayumova & Harper, 2020; Suárez & Otero, 2014). When seeking to expand teachers' conceptions of science teaching and learning, it is essential to cultivate their **asset-based orientations.** By asset-based orientations, we refer to the way that teachers orient to the strengths and merits of students' ideas, experiences, and forms of participation. Such orientations are grounded in the assertions that students are capable of engaging meaningfully in science, and that their own intellectual resources support their sensemaking (Celedón-Pattichis et al., 2018). Asset-based orientations frame students' engagement in the classroom such that teachers orient to the brilliance of students, rather than ascribe to deficit views (Mejia et al., 2018).

Another central component for expansive conceptions of science teaching and learning is recognizing **onto-epistemic heterogeneity**, or "differences in perceived ways of being, thinking, doing, and interpreting," as

valuable for scientific sensemaking (Kayumova & Dou, 2022, p. 1099). Going a step further than asset-based orientations, valuing onto-epistemic heterogeneity refers to expanded considerations of "what counts" as intellectually generative for students' scientific sensemaking (Rosebery et al., 2016). Such expansive considerations include, for example, valuing "practices of argumentation and embodied imagining, the generative power of everyday experience, and the role of informal language in meaning making" (Warren et al., 2001, p. 532). This does not entail an 'anything goes' view of science instruction nor a rejection of dominant views of science, but rather a "conscious form of heterogeneity of learning and engagement" (Bang & Marin, 2015, p. 542) that centers the varied cultures, languages, and experiences of students as valuable for knowing and being in science.

Expansive conceptions of science teaching and learning also entail a recognition that Western, narrow ideations of science are rooted in colonial historicity, and continue to define "settled" expectations about who counts as a valid constructor of knowledge (Bang et al, 2012; Mignolo, 2010; Warren et al., 2020). This contributes to the systematic cultural exclusion of students who exist outside of these racialized, classed, and gendered norms (Kayumova & Dou, 2022; Ladson-Billings, 2007). It is therefore essential to support the development of teachers' critical awareness of such power and historicity, the deficit narratives they (re)produce, and structural and systemic inequities that shape students' opportunities to learn science. Madkins and McKinney de Royston (2019) refer to this "deep understanding of how schools and society operate to reproduce inequalities and are structured to differentially privilege certain experiences and forms of knowledge over others" as **political clarity** (p. 1325).

Methods

This study is part of a larger project aimed at cultivating PSTs' capacities for understanding, valuing, and responding to students and their ideas in ways that affirm their humanity and dignity. Each of the PSTs in this study are double majoring in a STEM field of their choice and in education, with the goal of becoming a secondary STEM teacher. In the semester from which the data are drawn, nine PSTs participated in the study.

The goals of the course at the center of this study are to develop PSTs' knowledge and curiosity about learners' ways of thinking and feeling, promote PSTs' critical awareness of their own prejudice and biases, and support PSTs to recognize learners' brilliance and honor their full humanity in designing and enacting instruction. PSTs engage in several course activities in service of these goals: (1) reading research and practitioner articles about student thinking and diverse ways of knowing; (2) engaging as learners in science and mathematics activities that require them to think deeply about concepts; (3) analyzing videos and transcripts of students engaging in mathematical or scientific inquiry; and (4) closely interacting with learners through a capstone "Learning to Listen" project, which requires PSTs to engage a group of learners in an open-ended science or mathematics question. Throughout these activities, PSTs are asked to critically reflect on their own experiences as leaners as well as on K-12 students' ideas and experiences. Using multiple data sources, including PSTs' written assignments and in-class discussions, we examined evidence of PSTs' expansive conceptions and explored how they manifested in their evolving ideas about science teaching.

We first cataloged each of the PSTs weekly discussion board posts where they reflected on course readings and analyzed videos of student thinking. Using a grounded theory approach (Charmaz, 2006), we then took several iterative passes reading the PSTs' discussion board posts and tracking instances of expansiveness. Examples of such instances included moments when PSTs discussed the merit in a student's idea and their sensemaking resources or reflected on larger societal narratives that shape classroom experiences. The first and second authors met weekly to discuss such instances and share their analytical noticings around them. Through this work and our ongoing discussions, we identified themes to describe the ways in which expansiveness surfaced in PSTs' engagement with the course materials, and how this expansiveness manifested in their ideas about science teaching.

Findings

Due to space limitations, here we illustrate our findings using data from only one discussion where PSTs reflected on an essay from Warren and Rosebery (2008), "Using Everyday Experiences to Teach Science." The themes discussed below, however, apply more broadly across posts and reflections. In this essay, the authors feature vignettes of students using their everyday experiences as resources for sensemaking about water cycle and gravity.

Research question 1: Expansive conceptions of science learning

Our first research question concerns the ways in which PSTs developed more expansive perspectives around science learning. In their analysis and reflection on the piece from Warren and Rosebery (2008), we saw clear

evidence of PSTs' expanding conceptions of science learning in how they oriented to students' everyday experiences and their valuing of heterogeneous ways of sensemaking. For example, PST Molly wrote:

> "The students seemed to be very good at applying what they were trying to understand to things that they had experienced in real life… even though their wording was not what I would have expected… it makes sense that students from different backgrounds would have different criteria on what makes water unusable. I just was not thinking about it and it surprised me."

Here, even though the students' language surprised her, Molly recognized the value of students' varied experiences as resources for their sensemaking about a complex scientific phenomenon. Through this comment, Molly acknowledged that her expectations ("their wording was not what I would have expected") and her sense of surprise were stemming from her failing to consider how students' experiences and backgrounds may engender heterogenous ways of sensemaking and expression.

PST's expansive conceptions also manifested in how they problematized deficit discourses. Reflecting on the reading, another PST, Serena, tuned in to "negative assumptions" sometimes held by teachers about the capabilities of students who speak languages other than English, which she refers to as "outlandish and antiquated." Such assumptions, Serena noted, can impact the learning experiences of culturally and linguistically diverse students by making "it seem as though the gap between what these students can learn and what they already know is so large that it might be futile to even try." Relatedly, another PST, Kendall, noted that these deficit narratives are reproduced by "a system where curricula and rules are centered around being White and the White experience." In this system, she writes, marginalized students must either "conform to the Whiteness of the schooling system… [which] is a very large burden to carry" or be "alienated."

Research question 2: Expansive conceptions of science teaching

With respect to conceptions of science teaching, we saw evidence of expansiveness in the ways PSTs described the importance of opening up and holding space for students' ideas as well as in their critical reflections on their own biases and practices. For example, in connecting Warren and Rosebery's (2008) essay to her future teaching, PST Adeline asserted that "Students can't possibly be blank slates, and I wouldn't want them to be," because students' everyday ideas are "resources for learning." Adeline acknowledged that even though it would be "challenging to imagine" how she might work to make disciplinary connections to students' everyday ideas, this is a goal she aspires towards in her future practice. In another reflection, Adeline noted:

> "Students bring knowledge to the classroom that forms their understanding…and teachers need to listen to students, understand their thinking, and then adapt their teaching to best fit their students' needs so they can better understand the whole concept… we need to learn to listen and not assert our own ideas, assumptions, or expectations on our students."

In this reflection, Adeline recognized that an important aspect of teaching is learning how to "listen to students" to "understand their thinking" instead of evaluating and judging learners based on one's "own ideas, assumptions, or expectations." This stance of decentering from one's own perspective to tune into students' is a productive beginning towards a more expansive framing of teaching, a framing that centers and holds space for students' own ways of knowing. PSTs also commented on the importance of attending to and confronting their own assumptions and biases that might stand in the way of enacting such instruction. For example, in thinking about her future teaching practice, Kendall reflected on how such introspective work and critical reflection is an essential "first step":

> "Our first step is to recognize that we can be biased. If we are able to examine our own behavior and biases, then we can also critique and adjust them. It would be beneficial to… ask myself 'who did I talk to the most in class?' or 'what students were most engaged? And did I work to engage some students more than others?'"

Discussion

In science education, there is a call to trouble narrow assumptions that (re)produce deficit narratives and injustices (Kayumova & Dou, 2022). This presents a unique challenge for science educators because dominant portrayals of science depict narrow framings of the discipline that bound what counts as ontologically and epistemologically valid, and marginalize students with divergent ways of thinking, knowing, and participating in science (Bang et al., 2012). As we seek to expand PSTs' understanding and appreciation of students' meaning-making repertoires beyond what has been traditionally valued, it is essential that we understand how PSTs begin to form more

expansive considerations for "what counts" as intellectually generative for science learning and "who counts" as capable of learning science. In our study, we found that such expansive considerations manifested in PSTs' developing insights about the brilliance and capabilities of students, their valuing of diverse perspectives and intellectual resources, and their recognition of the harm that deficit narratives cause to minoritized learners.

Additionally, we found that these expansive conceptions of science teaching manifested in PSTs' ideas about teaching science. As PSTs discussed and reflected on the practice of teaching, they tuned in to the importance of making space for students and their diverse ideas, responding to students' contributions and forms of engagement in affirming and humanizing ways, and critically reflecting on their own biases and assumptions. These teaching considerations are a crucial first step toward enacting teaching practices that honor students' humanity and agency in epistemically just ways. When teachers support students in bringing their whole selves to their science learning and value students' cultural, linguistic, and experiential repertoires as valuable for sensemaking in science, they send messages to students that they are capable, agentive, and brilliant (Robertson & Atkins-Elliot, 2017).

It is important to note here that, while we share here a picture of productive beginnings towards more expansive conceptions of science learning and teaching, we are not suggesting that these orientations are in any way a "finished product" or that these PSTs—or any teacher, for that matter—would "hold" and enact such conceptions at all times and in all contexts. Conceptions may indeed be contextually constructed and may change over time. In future research, therefore, it will be important to explore how these expansive conceptions may stabilize over longer periods of time, and how they might manifest, and perhaps shift, in interactions with students in the complex work of teaching. Relatedly, there is a need for continued research on the design of educative experiences and support structures that uphold both preservice and in-service teachers in the work of problematizing and desettling dominant discourses around science, science learning, and science teaching, towards cultivating more expansive and humanizing science learning environments.

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