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# Learning to Listen: Cultivating Pre-Service Teachers' Attunement to Student Thinking

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**ABSTRACT**

Reform efforts in science and mathematics education highlight students' experiences and sensemaking repertoires as valuable resources for instruction. Yet, there is much to learn about how to cultivate teachers' capacity for eliciting, understanding, and responding to students' contributions. We argue that the first step of this cultivation is teachers' *learning to listen*: to attune and attend to the novel ways that students make sense of scientific phenomena and the natural world. While this notion of listening as critical to teaching is intuitive, the work behind it can be challenging. As such, this study explores promises and tensions of learning to listen through the journey of one pre-service teacher and examines her shifting views on teaching as related to her reflective practice around the work of listening. Focusing on listening as a core tenet of teaching, we discuss implications for teacher education to center listening as an instructional target for teacher learning in science and mathematics education.

**KEYWORDS**

Learning to listen; reflective practice; responsive teaching; STEM education; STEM teacher education

## Introduction

Reform visions for science and mathematics education (Council of Chief State School Officers [CCSSO], 2010; National Research Council [NRC], 2012) advocate for K-12 students to engage in disciplinary learning in ways that go beyond canonical knowledge and procedures toward engaging students in constructing and critiquing knowledge (Engle & Conant, 2002; Ford, 2008). To align with such visions, science and mathematics classrooms must support students to draw on their personal experiences and meaning-making repertoires—including their cultural, linguistic, emotional, and experiential resources—to make sense of phenomena and solve problems (NRC, 2012; Warren et al., 2005). In such classrooms, teachers must pay close attention to students' contributions to identify and build on the productive beginnings in their thinking—what scholars have referred to as *responsive teaching* (Hammer & van Zee, 2006; Hammer et al., 2012; Levin et al., 2012; Robertson et al., 2016). While such teaching is understood to promote disciplinary engagement, student agency, and equitable participation in science and math classrooms (e.g., Atkins & Frank, 2016; Ball & Bass, 2009; Colley & Windschitl, 2016; Rosebery et al., 2016), there is still much to be learned regarding how teachers take up and enact responsive teaching and how they may be supported in their teacher education programs to do so.

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A core premise of responsive teaching is that, in order to have something to *respond to*, teachers must make space for students to meaningfully explore phenomena and share their thinking (Hammer et al., 2012; Levin et al., 2012; Robertson et al., 2016); all the while, teachers must be closely attending to and interpreting students' contributions to identify productive disciplinary "seeds" (Robertson & Atkins Elliott, 2017) upon which to build their instruction. In other words, responsive teachers *listen* to their students in ways that attend to the disciplinary substance of their ideas and that recognize and honor the merits in their lines of reasoning.

Supporting teachers to enact responsive teaching therefore requires providing them opportunities to engage in the work of listening. But how does one learn to listen in ways that support and align with responsive teaching practices? And what are some "listening" opportunities that can trouble didactic and transmissive views of teaching, as well as disrupt deficit-oriented conceptions of learners to foster responsive visions of instruction? These questions motivate us to explore the journey of one pre-service teacher, Janet, who came to value listening to students as an inherent aspect of teaching; such listening, in turn, supported her to embrace more responsive views of instruction. Through this exploration, we aim to develop in-depth understandings of how Janet came to recognize the value of listening as a core component of teaching. The insights garnered in this study, we propose, have implications for teacher education aimed at cultivating teachers' capacity for listening and responding to students.

## Listening as core aspect of human interaction

The act of listening to others to understand their ideas, feelings, and experiences has been described in a multitude of ways—such as active, intentional, attentive, deliberate, deep, or even conscious listening. Listening to understand others has been recognized as an important and necessary skill across many disciplines, particularly those related to "helping professions" (McNaughton et al., 2008), including social work, nursing, human services, and counseling (e.g., Bunkers, 2010; Davis et al., 2008; Duhamel & Talbot, 2004; Fassaert et al., 2007; Frederickson, 2013; Mansfield, 1991; Meldrum, 2011; Paukert et al., 2004; Thomas & Pollio, 2002).

Beyond its importance in professional settings, listening is a core feature of the human experience. Not only is listening essential to learn about someone else's needs, experiences, and ways of being in the world, but it has the power to make others feel heard, seen, and valued (Batson, 2009; Hochschild, 2019; Horsthemke, 2015; Teuscher et al., 2016). Listening intently with the goal of understanding someone else's ideas, feelings, and experiences can therefore be deeply humanizing. It is not surprising then that such listening has been referred to as an act of care and empathy (Batson, 2009; Burroughs & Tollefsen, 2016; Fricker, 2007; Gerdes, 2011; Jaber et al., 2018), and even an act of love (Isay, 2008). That said, listening *to understand* can be challenging. As Covey (1989) remarks, often we do not listen to understand; we listen to reply. Learning to listen with the genuine goal of understanding and making sense of someone else's experience is therefore a skill worth pursuing and, as we discuss next, a particularly important one for teachers who aim to be responsive to their students.

### The importance of listening for responsive teaching

The idea of listening to students' ways of reasoning is not a new one by any means. Constructivist and sociocultural learning theories are built upon the premise that making sense of how someone is reasoning and constructing ideas necessitates tuning into and *hearing* how they are reasoning and how their thinking is coherent and sensible *to them* (Confrey, 1991; Dewey, 1916/1952; Garrison, 1996; Ginsburg, 1997). In science and mathematics teaching, listening with the intent to identify merits in student thinking is central for supporting students' sensemaking about the work, their epistemic agency, and their sense of self as capable thinkers and meaning makers (Ball, 1993; Hammer, 1997; Hammer & van Zee, 2006; Stroupe, 2016).

Yet, listening *to understand* student thinking is not a simple task as students' ideas, questions, and curiosities can be varied and complex and, at times, unfamiliar to their teachers. Additionally, there are many ways that a teacher may orient to what they hear when they make space for and listen to student ideas. That is, *how* teachers listen and what they listen *for* can have different consequences for how they interpret and respond to students' contributions. As psychiatrist Jon Frederickson (2013) notes, "if five people listen to the same person, they would often come away with five different impressions. Why? Because we listen *for* different things. *What we hear when we listen depends on where we focus our attention."* (p. 2, emphasis in original). If the teacher is listening for "correctness" with the purpose to interject and rectify student thinking, then they may only take up student contributions that are aligned with the canon (Robertson & Atkins Elliott, 2017; Rosebery et al., 2016). Moreover, if the teacher is primarily focused on their next moves, such as their responses and goals for the lesson, they may overlook many of the students' contributions and fail to recognize their intellectual merits.

In order to build on students' contributions, teachers must listen with the goal of understanding, a skill which necessitates patience and practice. Listening to understand requires holding space for ideas that do not align with teachers' own perspectives or content goals for their lessons, as well as a capacity to put on hold evaluations of correctness, particularly when there is discrepancy between teachers' and students' frames or meanings (Teuscher et al., 2016; Vorauer, 2013). As noted by Confrey (1991), "*teachers must learn to listen and hear the sense* and alternative meanings in [students'] approaches" (p. 111; emphasis added) in order to respond in ways that intellectually respect and leverage those meanings. Building on Confrey's (1991) work, Arcavi and Isoda (2007) argue that in order to understand the "possible sources and entailments" of student thinking, one must actively and intentionally engage in "analyzing what one hears and making the *enormous intellectual effort to take the 'other's perspective'* in order to understand it on its own merits" and make deliberate and well-informed choices that "productively integrate students' ideas" within instruction (p. 112; emphasis added). Similarly, Robertson and Richards (2016) argue that the "primary task" of responsive teachers is to intently tune into student thinking in order "to recognize disciplinary opportunities" within their thinking (p. 42) so that they can build on and leverage these opportunities in their teaching.

In short, the act of listening to students for the goal of understanding and building on their thinking and perspectives is difficult and complex. At the same time, it is an indispensable element of teaching responsively. To respond in ways that honor and elevate students' contributions, teachers must *listen* with openness, curiosity, and humility, with the

intent to understand how students are thinking and reasoning. However, the act of listening is not commonplace in science and mathematics teaching due to a long-standing tradition of lecture-based, confirmatory, instrumental instructional practices (Banilower et al., 2018; Capps et al., 2012; Stroupe, 2016). Such instructional practices—which typically prioritize students' acquisition of canonical knowledge—tend to position teachers as the central authority and knowledge arbiter in the classroom. This positioning compels teachers to listen to students' contributions with an eye toward evaluating them based on correctness rather than to understand *how* students are reasoning and identify merits in their thinking.

Many preservice teachers (PTs) who enroll in teacher education programs recognize such traditional classrooms as resonant with their own experiences as science and mathematics learners (Kang & Windschitl, 2018; Lortie, 1975; Stroupe, 2016). Such experiences may shape PTs' ideas about teaching as didactic and transmissive (i.e., telling students what they should know). Moreover, even when PTs—or experienced teachers for that matter—view responsiveness to learners as an important aspect of their instruction, several factors may complicate teachers' enactment of responsive teaching (Capps et al., 2012; Kang & Windschitl, 2018; Santagata et al., 2005). Teachers may feel anxious about following student lines of thinking without knowing where they will lead (Jaber et al., 2018) or worry that pursuing divergent interests, questions, and ways of reasoning could potentially lead away from disciplinary knowledge (Maskiewicz, 2015; Radoff et al., 2018).

In light of these complexities and potential teacher anxieties with respect to responsive teaching, learning to listen for nuances and merits in student thinking—especially when that thinking diverges from the teacher's or from the canon—becomes all the more a critical skill to cultivate through practice, guidance, and self-reflection.

## Reflective practice for learning to listen

Research on teacher learning has widely documented the importance of reflection on one's teaching practice (Beauchamp, 2015; Clarke & Hollingsworth, 2002; Danielowich, 2007; Rodgers, 2002). Studies have shown that teacher reflection on the enactment of new teaching skills or pedagogical strategies is instrumental for their growth and for refining their practice (Beauchamp, 2015; Clarke & Hollingsworth, 2002; Guskey, 2002; Opfer & Pedder, 2011). In other words, as they "try out" new ideas or practices, the work of reflection allows teachers to make sense of an enactment experience and develop deeper understandings about its connections to other experiences, ideas, beliefs, and practices (Rodgers, 2002). As teachers reflect on the specific goals of their practice, they may identify "the mismatches among what they *want* to do, what they *think* they are doing, and what they *actually* do" (Danielowich, 2007, p. 630, emphasis added), which in turn, can support learning and growth over time and across multiple aspects of teachers' professional, personal, and pedagogical domains (Clarke & Hollingsworth, 2002).

Research on teacher learning has long documented the benefits of teacher reflection. While such research does not often call out and investigate learning to listen as a focal phenomenon of inquiry, it provides compelling evidence for the power of reflection in support of teachers' learning to listen. Efforts such as teacher video clubs wherein groups of teachers watch, discuss, and reflect on videotapes of classroom episodes (their own or others) have been shown to hone teachers' attention to and interpretations of student thinking (Barnhart & van Es, 2015; Johnson & Cotterman, 2015; Sherin & Han, 2004; van

Es & Sherin, 2010). Similarly, approaches like teacher rehearsals and role play activities within teacher preparation have been shown to support teachers' attention to student thinking through repeated opportunities to enact and reflect on teaching while also getting real-time feedback from teacher educators and peers (Davis et al., 2017; Grossman et al., 2009; Kazemi et al., 2016; Lampert et al., 2013).

We argue that this line of research implicates the important work of learning to listen through repeated practice and intentional self- and guided reflection. Reflection on one's own efforts to listen can support teachers to become aware of what they are attuning to when listening to students, recognize the biases they may hold and tensions they may experience around the act of listening, and shift their focus toward listening to understand the underlying ideas and lines of reasoning of their students rather than listening for canonical or procedural "correctness" alone.

In sum, our work takes up the premise that engagement in reflective practice is of central importance to supporting teachers in learning to listen to students to understand their perspective and sensemaking efforts. In this study, we explore the learning journey of one PT (Janet) in an undergraduate science and mathematics teacher preparation program as she came to understand the value of listening to students with openness rather than judgment, and saw listening as central to her role as a teacher. We examine tensions and shifts around Janet's understandings of what it means to teach in responsive ways and the role of listening therein.

## Methods

### *Study design and context*

This qualitative case study is part of a larger project focused on the cultivation of teachers' asset-based orientations to students' diverse ways of thinking and feeling in science and mathematics. The case study is situated in a course occurring early in the coursework progression of a dual-major undergraduate science and mathematics-focused teacher education program at a university in the southeastern United States. The course was designed to support PTs to *learn to listen* to student ideas and lines of reasoning without judgment. In doing so, the course aimed to foster PTs' capacity to take on learners' perspectives and to develop a stance of humility and curiosity toward learners' ways of thinking, feeling, and being in science and mathematics, particularly when those ways do not reflect normative practices and discourses. Aspects of the course were also aimed at fostering a critical awareness of PTs' own biases and assumptions and how these may serve to influence and shape what they value and enact in their teaching.

With these goals in mind, the course engaged PTs in a constellation of activities wherein PTs had opportunities to practice the work of listening and tuning to students' contributions. Such activities included reading articles on students' diverse ways of thinking and feeling in science and mathematics; analyzing episodes of student thinking in videos and transcripts; and engaging in science and mathematics explorations as learners and reflecting on those experiences. In each of these activities, PTs were encouraged to take note of ideas that were particularly challenging, novel, or in contrast to their own ways of thinking in effort to support their ability to attune and attend to the contributions of others. Likewise,

every course activity included opportunity for verbal or written reflection to encourage PTs to make connections to ideas and concepts highlighted in the course—such as the work of listening to understand student reasoning, notions of responsive teaching, and the importance of honoring students' cultural and linguistic repertoires—and to their own experiences as teachers and learners.

PTs also participated in a field placement experience at a school serving primarily Black and Hispanic students and low-income families. As part of this field placement, PTs spent one hour each week in a science or mathematics classroom observing and engaging with upper elementary and middle school students. PTs reflected on those experiences weekly in journal logs where they documented details for each visit, with attention to moments of student thinking they found interesting, puzzling, or vexing. For the semester from which this study data are taken, the field placement was cut short due to the COVID-19 pandemic; however, PTs were able to spend at least four hours working side-by-side with students in their field placement.

The capstone project for the course was the "Learning to Listen" (LtL) project, wherein PTs engaged in interviewing others, such as peers, family members, or friends, to elicit their thinking around science and mathematics questions. Examples of such questions included: Does a ceiling fan lower the temperature of a room? Without counting one-by-one, how many squares can be made on a chess board? The goal of the LtL project was not to teach, correct, or direct participants toward a particular answer, but rather to *listen* to someone else's reasoning and ideas with the purpose of understanding and asking questions that would further elicit their thinking. Over the course of the semester, PTs conducted three separate LtL interviews; the first and second interviews were with a single participant at early and middle points in the semester and the third interview was conducted with a "focus group" of three-to-five participants at the end of the semester. PTs recorded and transcribed their interviews and submitted a reflective analysis of their enactment where they discussed the interviewees' thinking, reflected on their own actions and feelings as a facilitator, and described the challenges and rewards of the experience.

As a summative reflective assignment, PTs submitted a final "meta-moment" paper in which they were asked to reflect critically about their experiences and learning throughout the semester, including: descriptions of major insights developed in relation to the course; aspects of the course found to be most thought-provoking and productive for their learning; ways in which PT ideas about what it means to learn science and mathematics had changed; and reflections on areas of personal practice as science and

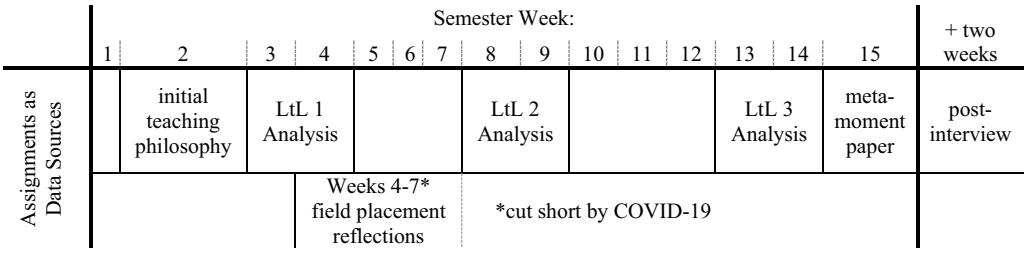


**Figure 1.** Timeline of course assignments and activities serving as data sources.

mathematics teachers and learners that PTs hoped to strengthen or refine. Several PTs also participated in a voluntary post-semester interview designed to further elicit additional reflection on PT learning and overall experience in the course, Figure 1 depicts a general timeline of the assignments and activities that serve as data sources for this study.

### Focal participant

In this study, we focus our analysis on Janet, a White female student who at the time was in her third semester of the science and mathematics teacher education program. Janet was chosen as a focal participant because of her ability to thoroughly express her thoughts, feelings, and reflections about her learning and experiences during the whole of the semester. In addition, Janet's reflections stood out in that she centered listening as an area that she hoped to grow in and refine in her teaching and often reflected on progress she felt she was making in her learning to listen as well as making explicit the processes of her thinking as she engaged in this work. While her experiences are representative of other PTs in the course in many respects, Janet's ability to articulate her experiences and particularities in such detail have allowed us to examine her experiences on a deeper, more fine-grained level (Creswell & Poth, 2016; Yin, 2009). Therefore, Janet's case provides a unique opportunity to understand the complex work of *learning to listen* as an aspect of teacher learning and growth.

Throughout her engagement in the course, Janet was highly reflective and critical around her own experiences as a learner in science and mathematics classrooms, both in K-12 and in college. On multiple occasions in class and in her written reflections, Janet remarked that her math and science teachers were primarily focused on the delivery of content and "telling" students what and how to think. One example that showcases such an assertion comes from Janet's meta-moment; she noted that her K-12 learning experiences involved "the type of teaching where the teacher [is] like, 'okay, here's all the formulas and here's all the notes'—lecture, lecture, lecture in class and then you have to do a bunch of problems on your own". While her experiences as a learner painted a picture of STEM teaching more aligned with didactic and transmissive views, Janet displayed from the onset an openness to ideas that ran counter to such views. In her written reflections and assignments, field placement logs, as well as in class discussions, Janet earnestly shared her views and experiences, reflecting on her learning including feelings and vexations she was grappling with. She was also willing to participate in a voluntary post-semester interview (an informal "coffee chat" opportunity offered to all enrolled PTs) that asked PTs to reflect on their overall experiences of the course and to share insights about what was most useful to their learning.

### Researcher positionality

The research team involved in this project brings a suite of experiences and perspectives to this work, as each member has taken on a variety of roles and different levels of participation with respect to the course at the center of this study. The first and second authors had been co-teaching the course for more than five years and have taken an iterative design-

based approach to the course activities and structures with the goal of supporting PTs asset-based orientations to learners. Both the first and second authors have been involved in research efforts related to the course and to pre-service teacher learning more broadly. The third author joined the team more recently, serving first in only a research capacity and now as a teaching assistant for the course as well. Before the semester associated with this study, the third author was a student in an earlier iteration of the course. Her familiarity and experience with the course material has allowed the third author to offer insights from an angle that is different from those of the other two authors.

As designers and instructors of the course and given our goal to support teachers' attunement and responsiveness to students' contributions, we strove to do the same in our own interactions with PTs. We therefore worked to hone our own capacity for listening and responding to PTs' ideas, vexations, feelings, and experiences within the course, and engage in reflective analysis of our own teaching practice individually and as a team in an effort to embody and model these practices for PTs and to inform and refine our own practice.

## *Analytical approach*

While PTs' LtL enactment data has provided fruitful insight into their in-the-moment interaction with student thinking and reasoning (see Jaber et al., 2023), this present work is focused on understanding the experiences, tensions, and learning around the work of learning to listen from PTs' own perspectives and reflections. Therefore, the primary data for this case study include Janet's three LtL reflective analysis papers which were submitted after each LtL interview enactment. Additionally, we draw on Janet's final meta-moment reflection paper from the end of the course, her weekly field placement logs documenting her experiences with students, and a post-semester semi-structured interview where she reflected further on her experiences and takeaways from the course. This interview took place over the telephone with the first author two weeks after the end of the semester, was audio-recorded and transcribed, and lasted approximately one hour. Each of these focal data sources were chosen because of their reflective nature and the insights they provide regarding Janet's understanding of her own progress and her awareness of her shifting views of teaching.

Rooted in constructionist grounded theory (Charmaz, 2008), the research team took an emergent thematic approach (Patton, 2002) to analyze each of Janet's three reflective analysis papers from the LtL project. The research team specifically attended to Janet's expressions of ideas regarding the role of listening in teaching, and the excitements, challenges, and realizations regarding listening to students that she experienced through each iteration of the LtL enactments. We also documented instances when Janet reflected on "next steps" in terms of her learning to listen as well as what she would have liked to do differently if she could have "paused the tape" during the LtL interview (e.g., following up on certain participant ideas by asking additional probing questions, offering more wait time, or refraining from interjecting her own thinking). Each of the three team members analyzed each LtL reflection individually. We then convened to discuss our initial pass as a group and to discuss emergent themes. We then collectively analyzed Janet's post-semester interview for similar ideas, paying close attention to her own reflections on her learning over the three LtL interview enactments and her descriptions of shifts in her views

of teaching. Additional reflective assignments (i.e., meta-moment paper, field experience reflective logs) were drawn upon to triangulate data and offer further evidence for the emerging portrait of Janet's journey in learning to listen.

After examining the data corpus for Janet's reflections around the work of learning to listen, we initially organized data excerpts chronologically to get a sense of her progression over time. However, in doing so we realized that Janet's journey was less linear and more fluid in nature. That is, rather than being a straightforward story of change-over-time, Janet's progression in learning to listen held more nuance and complexity than what we initially anticipated. To this end, we present our findings around three major themes emerging from the data which highlight the dynamic process of Janet's learning to listen, including insights she garnered and tensions she experienced as she engaged in and reflected on the work of listening.

## Findings

As Janet engaged in cycles of enactment and reflection centered on eliciting and attending to student thinking, these iterative and ongoing opportunities served as anchor points that offered her firsthand experiences with the power of listening. Through these experiences, Janet developed new insights regarding the work of listening to students as a central component of teaching. These insights included recognizing the importance of closely interacting with student thinking, acknowledging the tensions and challenges involved in listening to understand the substance of student thinking, and developing new understandings and ways of thinking about teaching. These insights, we argue, were driven and sustained by her *learning to listen*.

### *Recognizing the importance of closely interacting with student thinking*

As part of her efforts in learning to listen, Janet came to understand that a primary responsibility of teachers is to closely interact with student thinking by eliciting and responding to their ideas and building on their thinking in productive ways. These realizations became particularly salient for Janet as she worked with students in her field placement experience. As Janet and her peers worked with middle school students in math and science classrooms in the field, they were encouraged by the course instructors to look for opportunities to engage with students around sensemaking and problem-solving about math and/or science ideas, and to ask questions of students that would make student thinking visible and allow PTs to listen to and put effort toward understanding student lines of reasoning. In these encounters, Janet developed increased interest in delving into student thinking deeply to better understand their lines of reasoning. In describing one of her interactions with a student who was working on a problem related to dividing fractions, Janet noted her excitement for having understood the student's thinking who—although his answer to the problem was incorrect—had a sensible and reasonable line of thinking. Reflecting on this experience in her post-semester interview, Janet shared:

> There was a moment where [the student] got the wrong number, but I could very clearly [understand] *why* he got that number. So it was really interesting because I could see where his

> thoughts were coming from. I could literally and very clearly see where he was getting that number from. And that made me happy.

While Janet did not share the specific details about the student's thinking and the context surrounding it, her recollection of this "happy" moment as an experience that allowed her to "very clearly see" into the students' thinking is compelling. Janet uses language associated with "seeing" the student's thinking though she explains that it was the work of listening intently to the student that allowed her to ask probing questions and to ultimately understand his reasoning:

> I wasn't telling him "Oh this is wrong." I was like, "Okay well, how did you get this?" And "well, what if you looked back at this one—what did you do here?" That was definitely the best part of [my field experience], I think, was working with that one kid. (post-interview)

Janet expressed a sense of satisfaction and fulfillment in being able to sit with the student's way of thinking and interpret his reasoning, a moment she referred to as the highlight of her experience in the field. In her log entry about this interaction, she described this moment of coming to hear and understand the student's thinking as "a really cool experience."

Also at her field placement, Janet had another encounter with a student that served as a powerful example of the importance of listening to student thinking to understand their lines of reasoning. In this episode, students were independently working at their desks and Janet was moving around the classroom, interacting with and observing students. During her post-interview, Janet shared that while stopping to check in with one student, she asked the student about a particular problem and the student gave the correct answer. Janet offered confirmation to the student saying, "okay, good" and then she continued walking around the room checking in with other students. However, Janet went on to describe the critical pivot point of this episode:

> [But] then I thought about it probably ten minutes later—like a whole ten minutes later, well maybe five minutes, I don't know—and I was like, wait a minute!, and I went back to the student and [I asked], "*why* [did you get that answer]?" [. . .] She couldn't explain it! So then I was glad I asked because I could've just left it and not [gone] back to her.(post-interview)

Janet's willingness to take the student's correct answer at face value is understandable, but her latent reaction and intuition to return to the student and ask her the follow-up question of "why" proved both fruitful and powerful in illuminating a misalignment between the student's answer and the student's thinking. Reflecting on this realization, Janet shared:

> This was a moment for me where I realized that asking about student reasoning is really important. It goes back to [the idea discussed in class of] don't just assume that if the student got the answer right that they know what they're talking about. Because I did that in the beginning. I did. I was like, "Oh okay, cool. She's got it—the right answer. No problem." So going back and asking this student "why?" was eye opening for me, for sure. (post-interview)

By returning to the student and pressing for an explanation to her answer, Janet made space for the student to share her reasoning and, in doing so, she had the opportunity to listen to the student's thinking—which, in turn, allowed her to note that the student did not have a solid conceptual grasp of the ideas discussed. In concluding her reflection on this episode, Janet shared that she wanted to continue to hone her listening skills through "asking the why" questions such as "why did you do this?" and "how did you get that [answer]?" She

shared that asking students such questions and listening carefully to their responses can allow "the students to really lead the problem solving and decision making" related to their learning.

In sum, having opportunities to reflect on and analyze her interactions with students and the substance of their thinking seemed to be particularly central for Janet's learning to listen. Reflecting on her overall experiences in learning to listen and the LtL enactments, Janet shared that she "found this to be a rewarding experience because I got to analyze ways that I can improve in this type of [student-centered] discussion" (meta-moment).

### *Recognizing the challenges, tensions, and effort required to listen*

Through her engagement with and reflections on learning to listen to students, Janet came to recognize tensions she felt in doing this work. Janet frequently reflected on the ways in which honing one's skills around listening to understand the substance of student thinking can be challenging, requiring time, patience, and ongoing reflection and practice. For as much as Janet experienced productive shifts and new insights into what student-centered teaching can be, she shared how aspects of her own experiences of enacting and practicing the work of listening were sometimes in tension with these new understandings. In her end-of-semester reflection when considering the rewards and challenges of facilitating the three LtL capstone interview activities—the goals of which were to elicit and respond to student thinking around a mathematics or science question—Janet wrote:

> In my experience with the [LtL capstone] interviews, it was difficult to really listen to your students and respond on the spot. Most of my productive thinking [has been] done during the analysis and I think it is going to take time to really get better at listening and responding to students effectively [in-the-moment]. (meta-moment)

In this excerpt, Janet surfaces a tension that is likely familiar to many practicing teachers: it can be hard to listen to and interpret the substance of student thinking "on the spot" in order to respond to and leverage their thinking in meaningful ways. However, having opportunities to "pause the tape" through playback and through close examination of transcripts allowed Janet to dig deeper into learners' lines of reasoning and to "productively think" about student ideas and make sense of them after the fact. Of course, moment-to-moment interactions with students require teachers to carefully listen to, interpret, and respond to the substance of student ideas *in real time* and Janet seems to acknowledge the difficulty of doing, recognizing that it will "take time" and practice to become proficient at listening in the moment.

Another tension Janet shared in her reflections was the difficulty of putting aside concerns of next moves or what to say during her own turns of talk as she engaged in the work of listening to students. In her meta-moment reflecting on aspects of the semester that were challenging, Janet shared: "I have noticed that I have a hard time really listening to students because I am too worried about the next step of the conversation." Janet further explained in her post-interview that during her first two LtL enactments she had been "so worried about [asking] the next question" that this worry impeded her ability to be present with student thinking:

> I was thinking about my agenda in terms of the questions that I already had set for myself and so I wasn't really fully listening and responding to the student because I was so focused on "oh

> what's the next question that I have" [. . .] I was really just so worried about "oh let me make sure I ask all my questions," and I didn't pay as much attention [to what they were saying] or respond to students as well as I could have.

With that said, Janet recognized her own growth as a listener related to this tension. Referring to her third LtL enactment, Janet noted that "this experience was really rewarding for me because I feel like I actually made progress from my last two interviews and was consciously thinking about things we've learned in this class while still being able to listen." Contrasting her first two LtL interviews with her final LtL enactment, she noted:

> [The third LtL interview] was really just a lot better because I was actually responding to [my participants] and just going along with what was happening. Unlike my past interviews, I was not sitting there trying to remember what questions to ask, or not knowing what to say after a student responds. In my past interviews, I had a hard time being a facilitator. I didn't know how to guide the conversation without leading students to the answer. Therefore, I would end up saying "okay cool," and I would move on to a new question. (post-interview)

While this excerpt suggests that Janet was developing comfort and facility with the work of listening over time, another tension surfaced for her in learning to tune into student thinking: the challenge of putting aside concerns about "correctness" of ideas and a desire to teach toward a specific content goal which, at times, conflicted with the goal of listening carefully to students' lines of reasoning. Janet reflected on this challenge during her post-interview noting how in her final LtL capstone activity, she sometimes slipped into teaching-as-delivery:

> [Around 30 minutes into the last LtL,] I definitely guided my interviewees toward an answer I was looking for and I feel that I could have facilitated it in a better way without pushing so hard in one direction. I started teaching more than listening in that section [of the LtL enactment].

Janet's awareness of sliding back toward a teacher-centered mode of instruction—of guiding students toward "an answer [she] was looking for"—offers insight into a prevalent tension that teachers experience in their efforts to listen to students. It is also evidence of Janet's recognition that listening is a skill that requires repeated practice, careful attention, and deliberate reflection.

In sum, while Janet grappled with varied tensions in her listening journey, she also became more committed to honing her listening skills as a teacher. More specifically, she came to recognize that listening to understand student thinking—instead of focusing on next moves or prioritizing correctness—is essential for responding to students in ways that honor their ideas:

> I've learned that it is easier to respond to students and guide the conversation when you actually listen to what they are saying! I think in my past LtLs I had a hard time listening because I was so worried about the next question. But the whole purpose is to respond to student thinking, and you can't respond without listening! (post-interview)

### *Developing new understandings and ways of thinking about teaching*

Janet's interactions with students and her efforts around learning to listen supported her to take up new ways of thinking about teaching. In her meta-moment, she expressed that she

felt "inspired" by the many opportunities to elicit and sit patiently with student thinking. She noted that her "idea of what it means to learn science and math has definitely changed" in relation to the work of learning to listen. She further explained that she came to appreciate the importance of listening, not only to understand, but also to foster student thinking. Reflecting on how these understandings shaped her ways of thinking about teaching, Janet shared:

> Allowing students to explore learning using prior knowledge and personal experience in discussion helps students draw connections between the content of the class and the world around them. A teacher could easily stand in front of a classroom and teach the content. But when you think about it, it's the same thing as "giving the students the answers." When students can figure out the "answers" on their own through discussion and exploration, they are more likely to truly understand and remember what they learned. (meta-moment paper)

As she explored these new ways of thinking about teaching throughout the semester, Janet consistently drew on her own experiences as a science and mathematics learner. These connections often led Janet to interrogate her former teachers' instructional practices in relation to the work of listening:

> Throughout high school, my teachers would have PowerPoints and example problems with formulas, and we would just have to learn what we are told and spit it back out on a test. I never knew [learning] could be so explorational. (meta-moment paper)

Janet's recognition that disciplinary learning can be "so explorational" points to her new ways of thinking about what teaching can—or should—look like when teachers prioritize listening to students instead of expecting them to "learn what [they] are told." Contrasting her own experiences as a science and mathematics learner with these newly developed understandings, Janet noted that "a whole other world" had opened to her. Reflecting on her new ways of thinking about teaching in relation to listening, Janet explained:

> Teaching is not about pouring information into the brains of your students. Instead, it is about engaging students in in-depth conversations [. . .]. It is important that teachers listen to—and understand—student thinking. (meta-moment paper)

## Discussion and implications

Research around teacher noticing and responsive teaching has often highlighted how teachers should elicit, respond to, and build on student ideas and lines of reasoning (e.g., Barnhart & van Es, 2015; Hammer & van Zee, 2006; Hammer et al., 2012; Johnson & Cotterman, 2015; Krist et al., 2023; Levin et al., 2012; Robertson et al., 2016; Sherin & Han, 2004; van Es & Sherin, 2010). Much of this work, however, focuses on how teachers take up and respond to students' ideas, instead of examining the act and processes involved in the work of *listening* itself. We have argued in this work that centering listening as a phenomenon of interest on its own right in explorations of pedagogical practice is important for both theoretical and practical reasons. First, if teachers are to respond and take up learners' contributions in ways that make students feel heard and seen, they must be able to listen with care and depth to students' ideas and to where those ideas are coming from. Listening, in other words, is the bedrock of responsive teaching. Second, by centering listening as a foundational pedagogical

practice in and of itself, we become more intentional within teacher education to cultivate teachers' capacity for listening and support teachers as they grapple with tensions and vexations inherent in learning to listen.

As illustrated in Janet's case, PTs may have underlying assumptions informed by prior experiences as K-16 learners that orient to views of teachers as *tellers* of information and as knowledge-authorities. This is understandable given the notion of "apprenticeship of observation" in teacher education (Grossman, 1991; Lortie, 1975; Westrick & Morris, 2016) whereby previous firsthand experiences as learners in K-12 settings may shape one's ideas, assumptions, and expectations for what constitutes K-12 teaching. Our work points to the need for purposeful and explicit reflection around the act of listening as a critical pedagogical practice to support PTs to interrogate and disrupt transmissive narratives about teaching-as-telling, in order to take up more student-centered and reform-oriented perspectives where teaching-as-listening becomes a guiding principle.

Our findings also show that teachers need opportunities to "try out" and enact listening, to sit with student ideas, and to practice being open to, curious about, and humble toward student lines of reasoning, especially if the notion of teaching-as-listening is a new concept. Through analyses of transcripts and videos featuring novel and non-obvious student reasoning in math and science, Janet was able to marinate on and think deeply about student ideas in low-stakes ways (i.e., not in a real-time classroom exchange) in effort to hear, analyze, and recognize the brilliance and potential in students' ways of reasoning. Similarly, in real-time encounters with student thinking in her field placement classroom and through the LtL capstone, Janet was able to realize that listening for understanding is about more than eliciting and responding to students. Providing PTs, then, with multiple opportunities to practice and reflect on listening across varying contexts (e.g., transcripts, videos, real-time encounters) is an important aspect of the process of supporting teachers to understand listening as an important part of teaching.

Given the critical importance of listening as a worthwhile aspect of teaching, this work warrants further exploration of and attention to supporting teachers—pre-service and in-service alike—in learning to listen. We recognize that this study is bounded by the fact that it follows one PT in a course *designed* to cultivate teachers' stance toward listening as a valuable aspect of teaching and to support them in the work of learning to listen. There are certainly other factors around listening and learning to listen that are not captured by this work that are likely important for understanding additional ways to support and shape teachers' capacities for listening to students. To this end, a fruitful next step for further research may include exploration of other factors—including teachers' backgrounds, prior experiences, epistemologies, and the like—that may support, hinder, or serve to develop teachers' capacities for listening as part of teaching.

This work also invites us to consider *what it is that teachers are listening for* when attuning to student contributions. Learning to listen as part of teaching means not only hearing ideas that are "correct" or "scientific," but also making space for and taking seriously those ideas and lines of reasoning which lie beyond canonical and normative ways of thinking and reasoning in science and mathematics—to see the productivity and "brilliance" of student thinking (Robertson & Atkins Elliott, 2017). To listen with care is to encounter a multiplicity of ways of thinking, and this requires teachers to be mindful of what they are listening for with regard to what counts as productive for math and science learning. As Frederickson (2013) notes, "Out of an overwhelming amount of auditory

information, we have to pick and choose. The question becomes whether we are aware of our bias and can shift from one focus to another" (p. 2).

From this lens, an additional effort that this research calls for is the exploration of the ways in which learning to listen is also, in part, becoming aware of and unpacking one's biases and assumptions. Learning to listen involves learning to notice what and who is being listened to, what is being privileged and normalized, whose ideas get taken up in the classroom, as well as whose patterns of communication and ways of being and feeling are being attended to and in what ways. We find that such explorations are of critical importance to the field as they have implications for who gets positioned as capable of engaging in science, mathematics, and related disciplines. These considerations are particularly important given the persistent marginalization of students from historically underrepresented populations—including those whose cultural, linguistic, and experiential ways of knowing may not fit the "expected" academic and disciplinary norms that are privileged in many science and mathematics learning spaces (Ballenger & Carpenter, 2004; Metcalf et al., 2023; Robertson & Atkins Elliott, 2017; Warren & Rosebery, 2011). If teachers are not made aware of such biases, they will continue to miss out on listening to and noticing the deep intellectual and competent sensemaking of their students, particularly students of color and other historically marginalized students. As such, attending to the ways in which learning to listen to student reasoning might support teachers to take up more expansive notions of "who counts" as capable of science and math learning and "what counts" as intellectually generative for such learning is a crucial area of investigation within teacher education (Metcalf et al., 2023).

This work therefore has important implications for teacher education and professional development programs. To support teachers to take up the work of listening to and appreciating the merit of student ideas, particularly when those ideas are non-obvious or non-canonical, teacher educators must design opportunities for K-12 teachers to engage in reflective practice around listening. Such opportunities might include activities such as those experienced by Janet in our study: written reflections, making explicit connections to previous experiences as a K-12 science and mathematics learner, analysis of novel ideas and reasoning through artifacts of practice (e.g., videos, transcripts), and encouraging reflection on missed opportunities that might inform future enactments of listening-as-teaching. In this way, this study aligns with recommendations in related lines of work on teacher learning to notice learners' thinking (Barnhart & van Es, 2015; Johnson & Cotterman, 2015; Sherin & Han, 2004; van Es & Sherin, 2010) while also calling out teachers' learning to listen as an important instructional target in and of itself. Of course, there are likely other kinds of experiences and supports not explored in this study that may equally engender teachers' capacities for listening and attuning to student thinking. Continued research in this area should explore these and other educative activities toward this end.

This work also highlights that teacher educators and professional development providers *themselves* need to listen carefully to teachers as they enact and reflect upon learning experiences designed to support their learning to listen. That is, teacher educators must take seriously the tensions and challenges that teachers express as they work to cultivate and enact listening as a central aspect of teaching; it is important to validate teachers' feelings and experiences as they learn to listen to students with care and patience. It is also important to be mindful of our own biases and assumptions as teacher educators as we learn to listen to the teachers with whom we work. Indeed, listening with the intention of decentering

one's own perspective in order to understand the reasoning of another and to recognize the validity in another's meaning-making efforts takes work, practice, and critical reflection. Therefore, teacher educators must develop supportive learning contexts where they can engage, alongside with teachers, in the critical and ongoing work of learning to listen.

Beyond the case at hand and implications for science and mathematics teacher education, an additional contribution of this work lies in the assertion that listening is a laudable process and skill from a humanistic perspective. Listening to others with the aim of understanding differing and diverging perspectives from one's own is a critical skill not only in efforts to create humanizing learning spaces, but also in creating thriving and inclusive societies. From this stance, learning to listen may be considered an essential learning goal not only for teachers in classrooms, but for all—including students. Engaging in the work of listening to understand the perspectives, experiences, and feelings of others necessitates intention and care on the part of the listener and, as such, learning to listen requires effort, practice, and opportunities to reflect and engage with others. By elevating listening as a central practice of teaching, we hope that efforts to support and cultivate more teachers who take up this work of learning to listen with curiosity and humility may in turn create more students who learn to listen to and empathize with others, both within the classroom and beyond. To this end, further research examining whether and how teachers who prioritize listening for understanding as central to their teaching foster this same practice as a classroom community norm for their students would be worthwhile as they model, emphasize, and reify listening as a tenet of their teaching practice.

## Conclusion

If we are to ask science and mathematics teachers to develop views of teaching and learning aligned with those advocated by current reform visions (NRC, 2012), then we must support them to value and be responsive to students' contributions in the classroom. One aspect of this work, we have argued, is supporting teachers to genuinely *listen* to students' contributions with patience and care. Teaching in ways that honor and value students' contributions and ways of reasoning *requires* teachers to listen to student ideas—particularly when such ideas are not intuitive, obvious, or aligned with the perspective of the listener. Therefore, teachers must be supported to understand the value of listening, to view listening as a central practice of teaching, and to develop and hone their own capacity for listening from a stance of humility and curiosity. Learning to listen to students' ideas in these ways, we suggest, is critical for cultivating inclusive learning environments that are responsive to learners and that affirm their agency, self-worth, and humanity.

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