Learning to teach science to multilingual learners: A study of preservice teachers

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This study investigates what eight preservice secondary science teachers learned about effective instruction for multilingual learners (MLs) over the course of a 13-month, post-baccalaureate teacher education program. The author shares implications for how teacher education courses and fieldwork experiences can strengthen preservice teachers' understanding of effective science instruction for MLs.
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Science learning for all students

Recent reform documents in the United States call for *all* students, including multilingual learners (MLs), to learn science in ways that are engaging, authentic, and relevant to their lives (National Research Council, 2012; NGSS Lead States, 2013). These documents emphasize attention to MLs, in part, because there were over five million multilingual learners in United States public schools as recently as 2021 (National Clearinghouse for English Language Acquisition, 2009). Indeed, across the United States, over 11% of students in K-12 settings are identified as MLs (Lee & Buxton, 2013). In short, preparing beginning teachers to adequately support their MLs in learning reform-based science should be a priority for all teacher education programs.

In this study, the author traced eight preservice secondary science teachers' understanding of effective ML instruction across their 13-month, post-baccalaureate teacher education program. To do so, the author conducted interviews with preservice teacher participants, as well as their mentor teachers and teacher education instructors, video recorded preservice teachers' classroom instruction three times, and collected their teaching performance assessment (edTPA) portfolios. The data were qualitatively analyzed to identify strengths and limitations in preservice teachers' understanding of effective science instruction for MLs. This analysis was guided by two research questions: (1) How did preservice science teachers' understanding of effective ML instruction change over time? (2) How did teacher education courses and field experiences serve to support or constrain preservice teachers' growth in understanding?

A situated perspective on teacher learning

This study is grounded in the situated perspective on learning. This perspective foregrounds the contextual and social aspects of learning. More specifically, learning is understood to occur in a context, and the context, associated activity, and tools contribute to what is learned (Brown et al., 1989; Greeno, 2006). Learning is also viewed as being immersed in and developed from social and discursive interactions (Lave & Wenger, 1991; Putnam & Borko, 2000). Further, learning is conceptualized as resulting from increased participation in a community's practices over time (Borko, 2004; Lave & Wenger, 1991). In sum, through a situated lens, beginning teacher learning is defined as developing knowledge of teaching through discursive interactions about and increased participation in the practices of teaching (Borko, 2004).

Principles of effective ML instruction

The effective instruction of MLs in science education is guided by four key principles (Aminger et al., 2021). One principle is *identifying academic language demands for MLs* (Aguirre & Bunch, 2012). This principle asks preservice teachers to attend to the language demands in each task they provide MLs, including when they ask students to share their thinking, to talk in small groups, and to write explanations for or arguments about scientific phenomena. Preservice teachers are encouraged to move beyond an exclusive focus on lexical demands (vocabulary) by attending to syntactical (sentence) and discourse demands as well. A second principle, *providing students opportunities for rich language and literacy exposure and practice* (Lee et al., 2013; Moschkovich, 2007), attends to the importance of preservice science teachers offering MLs multiple opportunities to engage in the discourse of science that will advance both their English language acquisition and their science learning. A third principle, *providing students with cognitively demanding work* (Ambitious Science Teaching, 2015), demands that MLs have the opportunity to engage in complex tasks that are often reserved only for non-ML students (Iddings, 2005). As such, preservice teachers should provide analytical tasks that focus on the practices, concepts, and core ideas outlined in the *Next Generation Science Standards* (NGSS Lead States, 2013). Finally, a fourth principle, *building on and using students' funds of knowledge and resources* (Moll et al., 1992), asks preservice teachers both to use MLs' native languages as a resource for learning and to recognize the diversity of MLs' interests, experiences, and connections to the community. These four principles were intentionally focused on in the teacher education program central to this study.

Teacher education program

The context of this study was a 13-month teacher education program located in the West Coast. The program included sets of courses and experiences designed to support their learning of effective ML instruction. Preservice teachers completed two academic language courses. These courses included discussion of MLs, provided foundational information about academic language (AL), and suggested practices to support English language development and disciplinary content. The courses emphasized academic language as an essential mediator of the teaching and learning process – as a way to support students' ability to access and communicate their understanding of core ideas (Dutro & Moran, 2003; Lee et al., 2013). Finally, preservice science teachers also enrolled in three science methods courses. These courses provided them with knowledge and experiences about the processes of teaching and learning science, curriculum design, reform-based instruction, and formative and summative assessments. The last of these three science methods courses focused explicitly on the teaching of science to MLs.

Participants included preservice science teachers, their respective mentor teachers, and their academic language and science methods teacher educators. The eight preservice secondary science teachers (five biology and three physics) comprised the entire cohort of science teachers who were enrolled in the teacher education program under study. All preservice teachers had the opportunity to student teach in at least one class with MLs, providing the research team with a chance to examine how working with MLs influenced preservice teachers' understanding. The seven mentor teachers were veteran teachers in the local high schools in the district. Finally, the six teacher educators were seasoned instructors with doctorates in the fields of language and literacy education or science education.

The full data set included individual interviews, video recordings from three classroom observations of each preservice teacher in his or her placement, and preservice teachers' performance assessment (edTPA) portfolios. Preservice teacher interviews were conducted five times over the course of the academic year, and focused on eliciting preservice teachers' understanding of the four principles of effective ML instruction discussed above. Mentor teachers were interviewed to ascertain their understanding of effective ML instruction and to determine the types of guidance they provided their preservice teacher mentee. Teacher educators were interviewed to understand how they conceptualized and taught effective ML instruction in their courses.

Preservice science teachers' understanding of effective ML instruction

Two salient themes were identified: (1) All preservice teacher participants grew in their understanding of *academic language* and ways to appropriately scaffold MLs' learning of language. (2) Preservice teachers differed in their understanding of the importance of including *language rich discourse opportunities* for their students, in particular, how such opportunities connected (or not) to *cognitively demanding tasks*.

Theme 1: Academic language

Over time, all preservice teachers showed growth in their understanding of this principle, moving from simplistic articulations of academic language as vocabulary, to more elaborate definitions in which they connected academic language to broader learning goals. Molly, for example, reflected on her growth:

> *"At the beginning, I definitely only thought of it [academic language] as words….But now, I am definitely starting to see it as more of the syntax as well and really making sure that students understand how a word could be used regarding integrating the topics that we are discussing."*

In this specific situation, Molly explained how her definition of AL was evolving to encompass a broader range of features at the sentence and discourse level. Moreover, she reflected on how she had developed a broader awareness of the importance of the sentence and discourse levels of AL in order to use AL to communicate with a certain audience.

Equally important, preservice teachers grew in their understanding of how to support their MLs' access to rich academic language. Early on, many, like Alex, thought it necessary to reduce language demands:

> *"Well, I stay away from giving them tasks that involve a lot of reading and writing. I give them cognitively demanding tasks that are inquiry based, and make them think about the topic rather than the words on the paper."*

In this case, Alex was not aware that academic language is truly intertwined with teaching and learning content, and it should be supported at all times. However, by the end, most, like Sacsha, understood academic language demands could be scaffolded rather than reduced:

> *"I'd been confused….I know we have to scaffold language demands, but I wasn't sure. Are they [language demands] good? Are they bad? Are we trying to get rid of the demands or do we help them meet the demands? I feel like the last part of the [science methods] course really helped clarify that they are good, but we need to scaffold them appropriately. Now, I feel it is okay to bring in lots of language, just to help them use it."*

More specifically, by the end of her teacher education program, Sacsha deepened her understanding of AL by helping students effectively communicate science to a particular audience. In fact, most participants learned to view academic language as an integral part of science itself – to understand that the teaching of disciplinary language cannot and should not be separated from the teaching of science content.

Theme 2: Language rich opportunities and cognitively demanding tasks

Overall, preservice science teacher participants differed markedly in their understanding of the importance of providing opportunities for their students to engage in rich discourse. By the end of their program, several preservice science teachers still had some difficulty in understanding the reciprocal relationship between rich language opportunities and science content learning. For example, for Kari, the learning of language and of science content remained somewhat distinct even at the end of her program:

> *"Especially not being an English teacher, it was like, how much time can we put [into language opportunities]? Does our schedule allow us to help them with the writing of this [assignment], when really we want like the concepts? But obviously, we're teaching them writing at the same time [as concepts]. But that was an intimidating [science writing] assignment for them [the students], and hard for science teachers [to implement] as well, because it's [writing is] not exactly our area of expertise."*

In this particular case, Kari noted she entered the teacher education program with a vague understanding of academic language, irrespective of levels, and described learning to see this construct as a critical component of science teaching and learning over time.

In contrast, a number of preservice teachers learned to see language rich opportunities as intimately connected to the implementation of NGSS ideas and practices – to the principle of cognitively demanding tasks. Adam, in particular, described tasks as a springboard to language:

> *"I really think that the cognitively demanding tasks that you choose are like springboards for language opportunities in themselves. The task is so rich in itself that there is a language-rich opportunity, whether it be speaking, listening, writing….And so I felt there was a huge correlation between those two. And then there's like this overall cognizance of what are we making our kids do? Are we just making them listen to us the entire time? Are we having them produce oral language? How are we having them produce written language? What supports do we need for both in getting our students to use academic language in that as well?"*

As was the case for all participants, Adam provided a meaningful context for language use. He grounded his lesson cycle in a discrepant evolutionary phenomenon and strategically grouped students, creating a need for students to talk science as they collaboratively analyzed data and constructed explanations. Like the other participants, he relied on peer collaboration and discourse moves such as probing, pressing, and re-voicing (Ambitious Science Teaching, 2015) to scaffold students' oral discourse. In general, the participants were willing to take responsibility for supporting the academic language demands of the cognitively demanding tasks they implemented by drawing on a robust range of strategies.

Contributions and implications to the teaching and learning of science for ML students

This study contributes to efforts to provide ML students greater access to science learning, a critical need identified in the *Next Generation Science Standards* (NGSS Lead States, 2013). As such, this work should be of interest to educators engaged in research on MLs, science teacher education, and/or reform-based science instruction. More concretely, the purpose in conducting this study was to identify ways to foster a shift in preservice science teachers from a naïve understanding that attention to vocabulary is needed to teach MLs, to the use of a set of principles to guide their implementation of reform-based science instruction.

Several implications were identified in this study. One implication is the need to more clearly articulate for preservice teachers how to appropriately attend to academic language demands in assignments and assessments. More specifically, teacher education courses could better emphasize the balance between recognizing academic language demands as a barrier to MLs' science learning and using appropriate scaffolds to maintain rather than eliminate the academic language included in science lessons. A related implication is that the construct of cognitively demanding tasks could serve as a linchpin for implementing language rich opportunities and appropriate academic language demands. As made visible in these findings, at least some of the preservice teacher participants found this principle useful in determining the kinds of language opportunities and supports needed to promote ML students' learning.

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